Middle Atmosphere Program

HANDBOOK FOR MAP VOLUME 26

Edited by
Belva Edwards

(NASA-CR-183350) MIDDLE ATMOSPHERE PROGRAM: HANDBOOK FOR MAP, VOLUME 26 (International Council of Scientific Unions) 79 p CSCL 04A

N89-17368

Unclas
G3/46 0171191

ICSU

International Council of Scientific Unions

SCOSTEP

Scientific Committee on Solar-Terrestrial Physics
J. G. Roederer, President
W. I. Axford, Vice President
C. H. Liu, Scientific Secretary

MAP ORGANIZATION

MIDDLE ATMOSPHERE PROGRAM STEERING COMMITTEE
S. A. Bowhill, SCOSTEP, Chairman
K. Labitzke, COSPAR, Vice Chairman
C. H. Liu, SCOSTEP, Secretary

H. S. Ahluwalia, IUPAP
R. D. Bojkov, WMO
A. D. Danilov, COSPAR
J. C. Gille, COSPAR
I. Hirota, IUGG/IAMAP
A. H. Manson, SCOSTEP
T. Nagata, SCAR
R. G. Roper, IUGG/IAMAP
P. C. Simon, IAU
J. Taubenheim, IUGG/IAGA
T. E. VanZandt, URSI
R. A. Vincent, URSI

MAP STANDING COMMITTEES

Data Management -- G. Hartmann and I. Hirota, Co-Chairmen
Publications -- Belva Edwards, Chairman

MAP STUDY GROUPS

MSG-5 Ions and Aerosols, F. Arnold and M. P. McCormick, Co-Chairmen
MSG-8 Atmospheric Chemistry, G. Witt, Chairman
MSG-9 Measurement of Middle Atmosphere Parameters by Long Duration Balloon Flights, J. E. Blamont, Chairman

MAP PROJECTS

	Coordinator
AMA:	T. Hirasawa
ATMAP:	J. M. Forbes
DYNAMICS:	K. Labitzke
GLOBMET:	R. G. Roper
GLOBUS:	J. P. Pommereau
GOSSA:	M. P. McCormick
GRATMAP:	D. C. Fritts
MAC-EPSILON:	E. V. Thrane
MAC-SINE:	E. V. Thrane
MAE:	R. A. Goldberg
MASH:	A. O'Neill
NIEO:	S. Kato
OZMAP:	D. F. Heath
SSIM:	P. C. Simon
SUPER CAMP:	E. Kopp
WINE	U. von Zahn

MAP REGIONAL CONSULTATIVE GROUP

Europe: M. L. Chanin, Chairman

MIDDLE

ATMOSPHERE

PROGRAM

HANDBOOK FOR MAP

Volume 26 ✓

Edited by
Belva Edwards

June 1988

Published for the ICSU Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) with financial assistance from the National Aeronautics and Space Administration under the 1987 Middle Atmosphere Program Management Contract and Unesco Subvention 1988-1989.

Copies available from SCOSTEP Secretariat, University of Illinois, 1406 W. Green Street, Urbana, Illinois 61801.

TABLE OF CONTENTS

PRECEDING PAGE BLANK NOT FILMED

MINUTES MAPSC MEETING

August 18, 1987
Vancouver, Canada

1. Bowhill welcomed the participants.

2. The Agenda was approved.

3. The Minutes for the last MAPSC meeting were approved.

4. Committee Reports:

Hirota presented the report for the Data Management Committee. He proposed to compile a MAP Data Catalogue following the format of the Japanese MAP Data Catalogue published in "Japanese Contributions to MAP". The Secretariat will send letters to MAP National Representatives with samples taken from the Japanese Catalogue, asking experimenters from their respective nations to send their contributions to Hirota by June 1, 1988 for compilation of the MAP Data Catalogue.

Publication Committee Report: A report prepared by Edwards was presented (Appendix 1).

5. There were no MSG Reports.

6. Project Reports:

Written Project Reports will be provided to the Secretariat by the Project Coordinators. Deadline was set for October 1, 1987. (See Appendices 2-8.)

Bojkov will find out the status of the manuscripts of the OZMAP Workshop in Salzburg in 1985 which were planned to be published as a volume of the MAP Handbook. He will let the Secretariat know when he has the information.

Roper reported a GLOBMET Symposium is planned for July 25-30, 1988 in USSR. It was pointed out that the dates conflict with COSPAR. Alternative dates July 11-16 will be considered.

7. New Projects:

EMA (Equatorial Middle Atmosphere) and EMMA (Energy and Momentum in the Middle Atmosphere): Kato and Bowhill mentioned the background of the two proposed projects and their relation to a new program being proposed to the SCOSTEP Bureau, Middle Atmosphere Study (MAS). The Committee agreed that both projects should be parts of MAS (see Appendix 9).

There was no report on NITROX (Nitric Oxide-Odd Oxide Study).

8. New Workshops:

Two proposals for Workshops were discussed. Super Camp: The project is planned for 1990. Planning for a Workshop on March 16, 17, 1988 at Boulder, Colorado, together with the Noctilucent Cloud Working Group is underway. Gary Thomas will organize it. The Committee approved the proposal.

MST Radar Workshop: The Fourth MST Radar Workshop will be hosted by Kyoto University in December 1988. Kato reported the preliminary plan which includes an International School for Radar Atmosphere Study. The proposal was approved.

9. There was no Regional Consultative Group Report.

10. MAP Planning Document:

Vincent reported the progress in revising the MAP Planning Document. Contributors of chapters have been identified. The deadline for submitting manuscripts is set at March 1988, to be published by the end of 1988. It was approved that the title of the volume be changed to "MAP Summary Document", with a one-page contribution from each Project leader. The Secretariat will provide Vincent with the names and addresses of the Project leaders.

11. Coordination with STEP

Labitzke reported that the STEP Steering Committee has been organized. MAP will have programs in STEP. There will be a STEP Symposium in Helsinki in 1988.

12. MASH/GRATMAP Workshop Report

O'Neill reported on the Workshop (Appendix 10).

13. MAP Symposium

Bowhill reported the planning of the MAP Symposium in Helsinki. The dates are July 18-23. MAPSC members constitute the Program Committee. The program tentatively will be based on MAP Projects. Those Projects that have had campaigns (ATMAP, DYNAMICS, GLOBUS, MAC-EPSILON/MAC-SINE, and WINE) will have one 1/2 day program each. Those Projects that have held regular workshops will have one 1/4 day session each (GLOBMET, GOSSA, GRATMAP, MAE). The other five projects (AMA, MASH, NIEO, OZMAP, SSIM) will fill one 1/2 day session. The Project leaders will be responsible to organize the sessions. Bowhill will write to them. The remaining one day is committed to the joint IGBP Symposium.

14. Reports from National Representatives

The Soviet MAP Representative Gretchko proposed to hold a Middle Atmosphere Symposium in Moscow in October 1989. The Committee approved it and will seek approval from the SCOSTEP Bureau.

Other National Reports are given in Appendices 11-14.

15. Other Business: None.

16. Next Meeting:

Helsinki, week of July 18, 1988, evening meetings. Exact dates to be determined.

A list of attendees is given in Appendix 15, and the agenda for the meeting in Appendix 16.

APPENDIX 1

MAP PUBLICATIONS REPORT

August 1987

MAP HANDBOOKS

HANDBOOK FOR MAP Volumes 19, 20, 21, 22, and 23 have been distributed since the last MAPSC meeting. Volume 24, an updated MAP Directory, is in the press. Unfortunately, gross misinformation furnished to the Secretariat has caused publication of this volume to be delayed about three months. However, it is now in proper channels and should be out this Fall.

Volume 25, papers from the GLOBMET Symposium, is in the mail to the printer; it should be available later in the Fall.

Future volumes will include the updated Planning Document, Minutes and reports generated at the Vancouver meeting, and papers from the final MAP Symposium to be held in 1988.

In order to avoid inordinate delays in publication, I would **strongly recommend** organizers of workshops and/or symposia to have authors prepare their papers camera-ready if they are to be published in a MAP Handbook. Format specifications will be furnished by the Secretariat.

MAP NEWSLETTER

The MAP Newsletter continues to be published in India in the charge of Dr. S. C. Chakravarty. Because of a lack of material received, it is now published semiannually instead of quarterly. If the Newsletter is to be effective, timely, newsworthy items must be sent to Dr. Chakravarty. His address is ISRO Headquarters, Cauvery Bhavan, Bangalore 560009, India.

Belva Edwards, Chairman
MAP Publications

APPENDIX 2

ATMAP
Status Report to the MAPSC of SCOSTEP
Jeffrey M. Forbes, ATMAP Coordinator

A 1/2-day workshop was held on August 21, 1987, during the IUGG Assembly Vancouver, Canada, focusing on the interpretation of monthly tidal climatologies between about 70 and 100 km obtained from 14 radars situated around the world. Various aspects of the seasonal, latitudinal, and height structures of the diurnal and semidiurnal tidal oscillations were identified and interpreted within the framework of available numerical models. These results form the basis for more indepth studies and collaborations, results of which will be presented as a series of invited and contributed talks at a 1/2-day science session entitled "Results of the Atmospheric Tides Middle Atmosphere Program", to be held during the MAP Symposium, Helsinki, Finland, July 18-23, 1988, just prior to the COSPAR Meeting (July 25-27). A tentative agenda for the ATMAP science session is attached.

'RESULTS OF THE ATMOSPHERIC TIDES MIDDLE ATMOSPHERE PROGRAM'
Helsinki, Finland
Tentative Agenda

1:00 J. Forbes, Chairman, The Atmospheric Tides Middle Atmosphere Program
1:20 Y. Portnyagin (invited), Soviet GLOBMET contributions to ATMAP
1:40 S. Avery (invited), High-latitude tidal behavior
2:00 A. Manson (invited), Global behavior of the height/seasonal structure of tides between 40° and 60° latitude
2:20 E. Kazimirovsky (invited), Midlatitude seasonal behavior of tides near the mesopause level
2:40 R. Vincent (invited), Asymmetries in tidal structures between Adelaide and Kyoto
Break
3:30 S. Kato (invited), Nonmigrating tides
3:50 F. Vial (invited), Recent accomplishments in tidal modeling
4:20-5:30 Contributed papers.

APPENDIX 3

THE STRATOSPHERIC WINTER 1986/87: A MAJOR MIDWINTER WARMING 35 YEARS AFTER THEY WERE FIRST DETECTED

B. Naujokat, K. Labitzke, R. Lenschow, K. Petzoldt, and R.-C. Wohlfart

Abstract

The main features of the stratospheric circulation during the winter of 1986/87 are described. The winter had four distinct periods: A cold early winter with the lowest monthly mean temperatures observed over the polar region since November 1955, a minor warming during the first half of December which was most pronounced in the upper stratosphere, a major midwinter warming in January/February which was one of the most intense warmings observed since their detection in 1952, and a pronounced late winter cooling in February/March, leading to an extremely late final warming which was not completed in the lower stratosphere until the middle of May. Finally, the ECMWF-prognoses for the 30-hPa heights are compared with the Berlin analyses.

Introduction

As in the years before, the main features of the stratospheric circulation during the winter are described. We have combined data from various sources in order to give as complete an overview of the middle atmosphere as possible. Mandated by WMO, during the winter the STRATALERT BERLIN message is prepared daily and is transmitted through the Global Telecommunication System to the Meteorological Centres. We are responsible also for the GEOALERT/STRATWARM messages, which have to issued when the magnitude of the warming reaches hemispheric extent.

For the preparation of these messages during the last winter, the Meteorological Office, Bracknell, UK, transmitted daily maps of radiances of the SSU (Stratospheric Sounding Unit, on board the NOAA satellites) and derived 10- and 1-hPa charts. Some of these data were used in Figures 1, 11 and 12.

The European Centre for Medium Range Weather Forecasts (ECMWF), Reading, UK, transmitted daily 3- and 5-day prognoses for the 30-hPa level. Figure 16 is based on these prognoses.

The University of Saskatchewan, Saskatoon, Canada, and the Geophysical Observatory Collm, GDR, transmitted information on the prevailing winds in the upper mesosphere, part of which is shown in Figure 12.

The Service d'Aeronomie du CNRS, Verrieres-le-Buisson, France, transmitted temperature profiles of the middle atmosphere as measured by lidar over Haute Provence and Biscarosse, France.

From the Geophysical Institute of the Czechoslovak Academy of Science, Praha, CSSR, we received a contribution on the ionospheric radio wave absorption over Central Europe, which is shown in Figure 13.

The Stratospheric Research Group, F.U. Berlin, analyzed daily maps for the 50-, 30- and 10-hPa levels, using radiosonde and rocketsonde data as well as thickness values derived from satellite soundings (SATEM). From these analyses, characteristic quantities were derived which

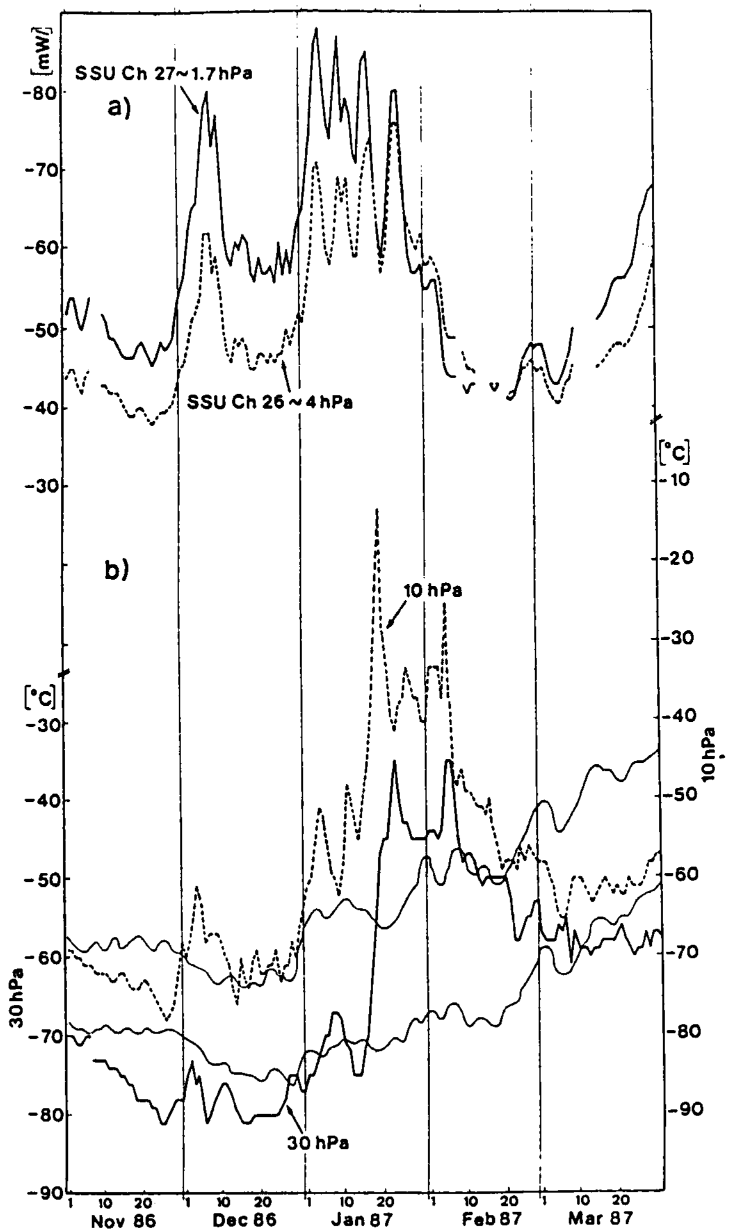

Figure 1. March of radiances and temperatures over the North Pole: a) Radiances (mW/m^{2}sr cm^{-1}) of channel 27 and 26 of the SSU, maximum weight around 1.7 and 4 hPa (courtesy Meteorological Office, Bracknell, UK). b) Temperatures (°C) at 10 and 30 hPa (thin lines are daily 20-year means).

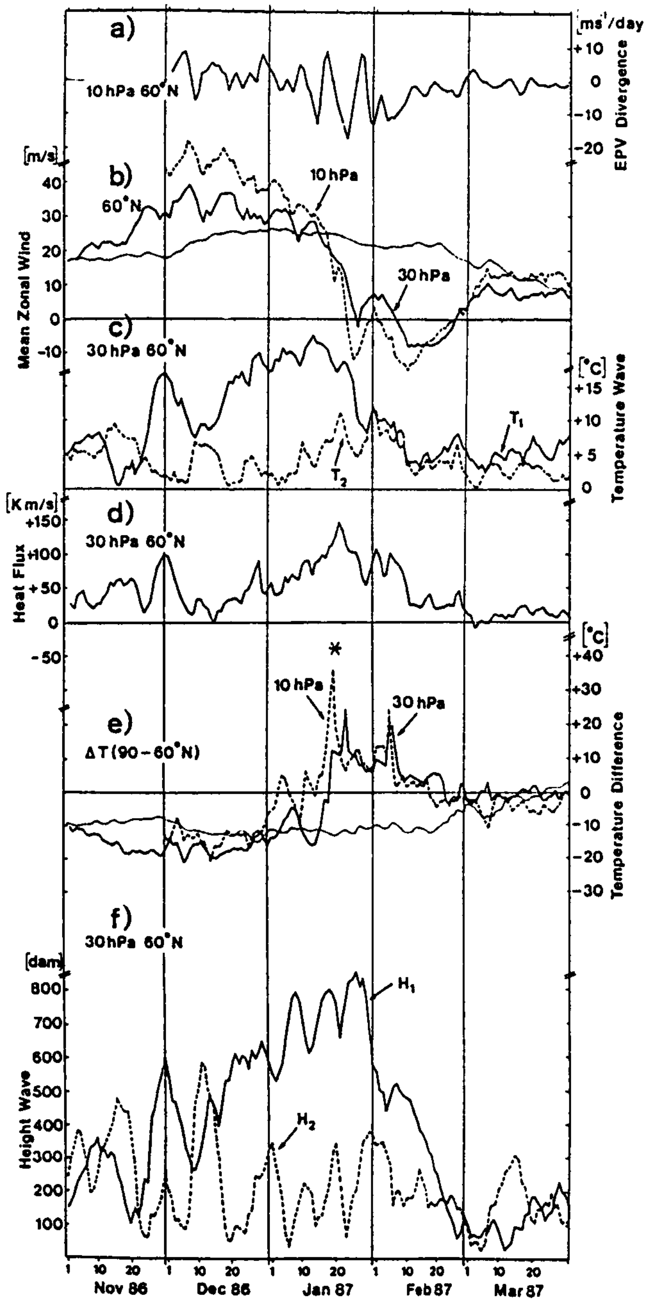

Figure 2. Derived quantities (daily values) describing the winter 1986/87: a) Divergence of the Eliassen-Palm-Vector (m s-1/day at 60°N, 10 hPa (3-day running means with 1-2-1 weighting); b) Mean zonal wind (m/s) at 60°N, 10 and 30 hPa; c) Amplitudes of temperature waves 1 and 2 (°C) at 60°N, 30 hPa; d) Heat flux (K m/s) at 30 hPa through 60°N; e) Temperature differences (°C) between 60°N and the Pole, 10 and 30 hPa; f) Amplitudes of height waves 1 and 2 (geopot. m) at 60°N, 30 hPa (thin lines in b) and e) are daily 20-year means).

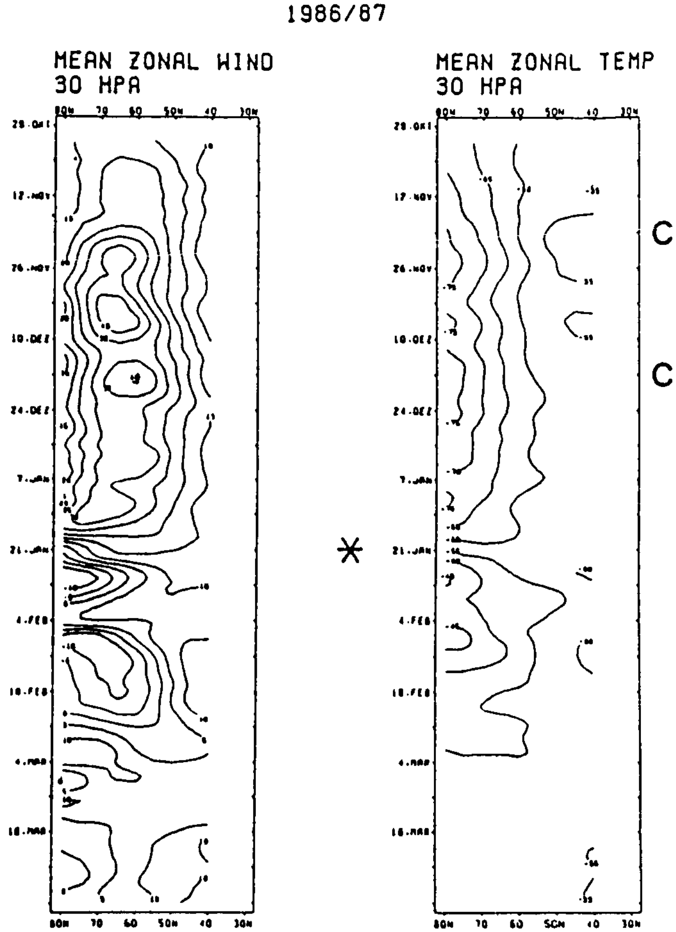

Figure 3. Meridional time sections from November 1986 to March 1987 of mean zonal wind (m/s) and mean zonal temperature (°C) at 30 hPa.

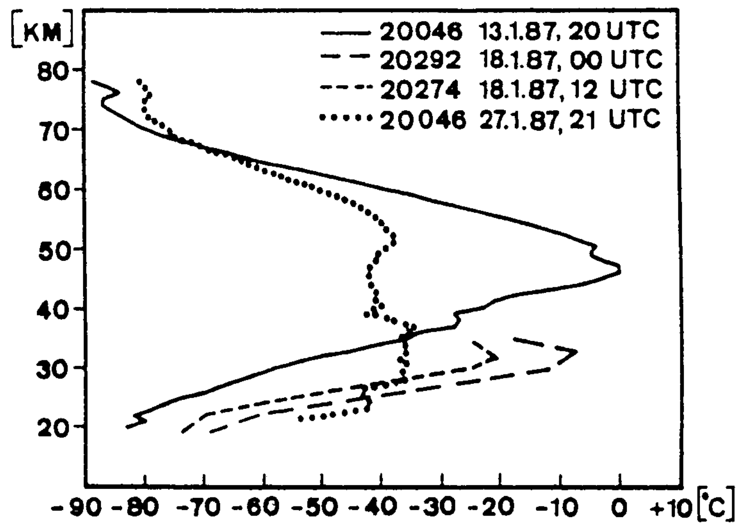

Figure 4. Vertical temperature profiles from rocket observations over Heiss Island on 13 and 27 January 1987 and from two adjacent radiosonde stations on 18 January 1987.

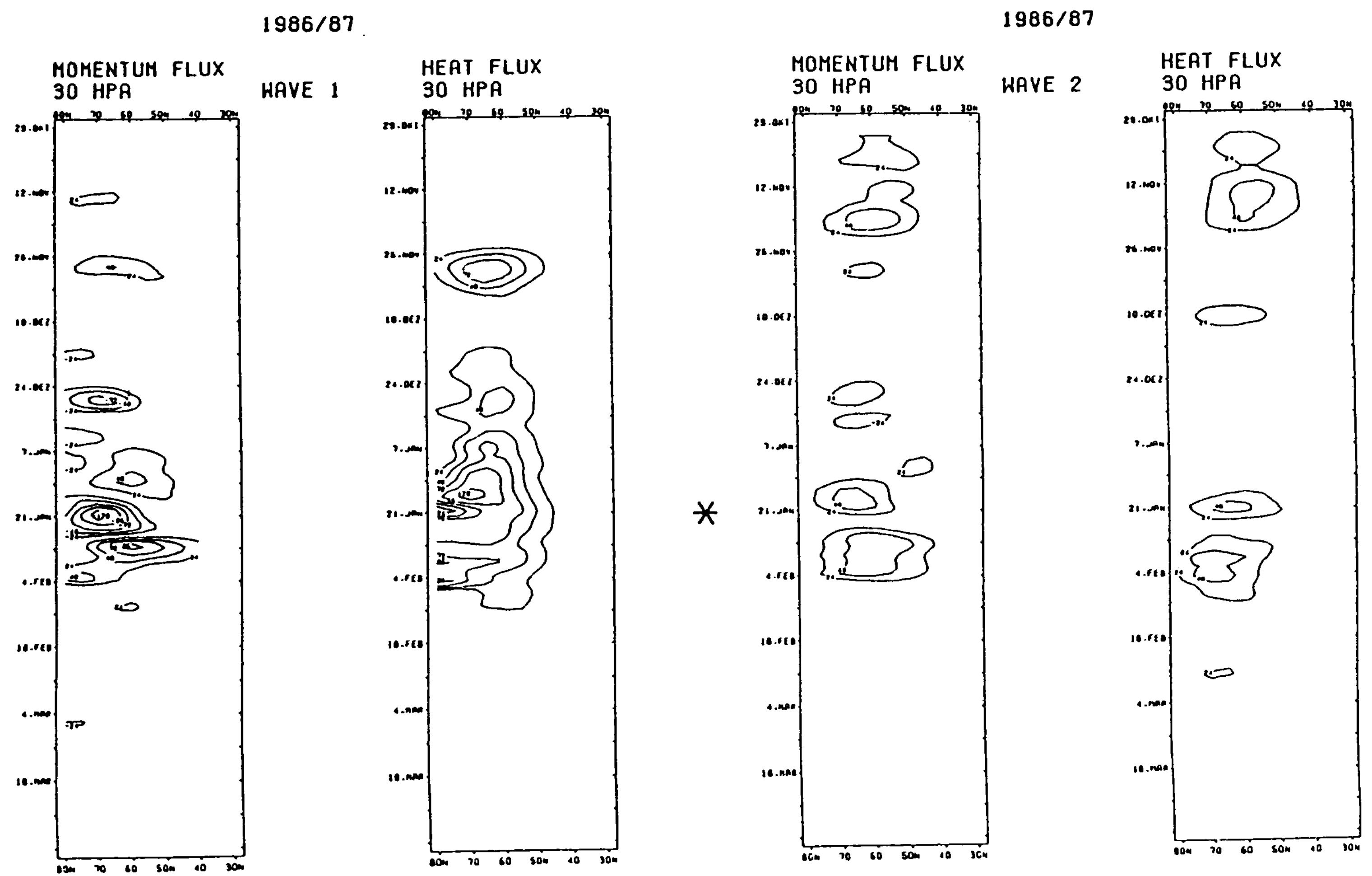

Figure 5. Meridional time sections from November 1986 to March 1987 of zonally averaged eddy momentum transport (m^2/s^2) and eddy heat transport (K m/s) by the planetary waves 1 and 2 at the 30 hPa.

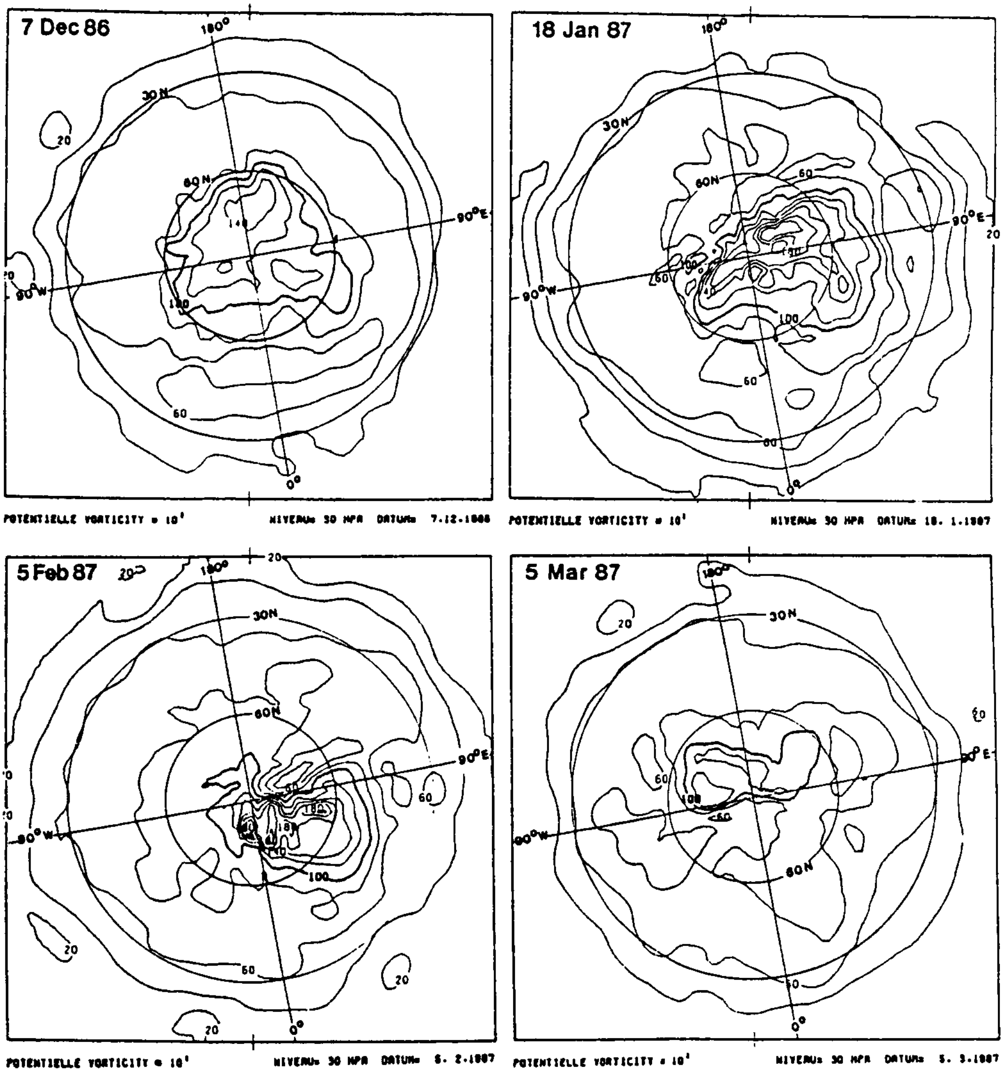

Figure 6. Potential vorticity (K hPa^{-1} s^{-1} x 10^5) at the 30-hPa level.

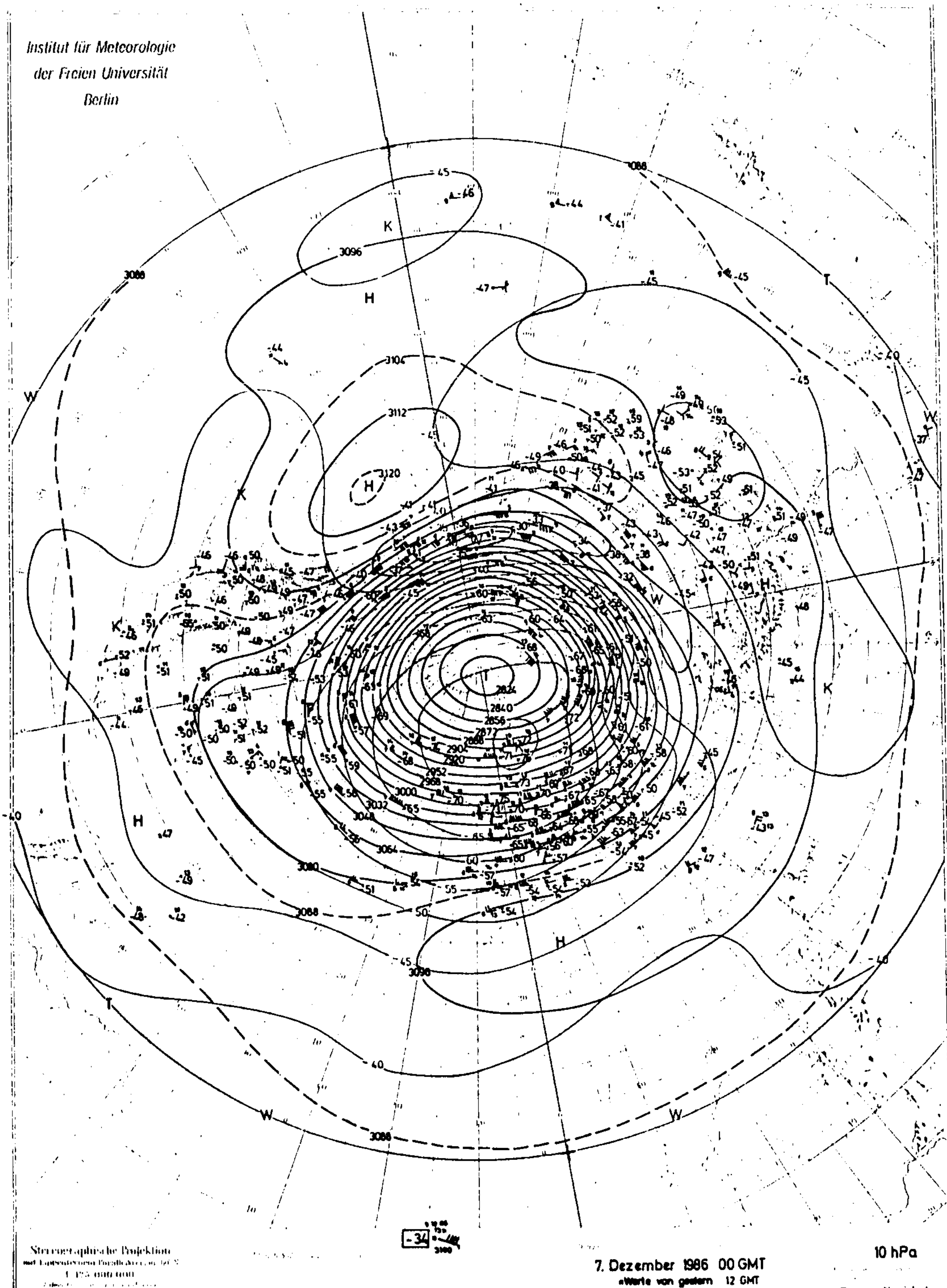
Institut für Meteorologie
der Freien Universität
Berlin
7. Dezember 1986 00 GMT
10 hPa
Naujokat

Figure 7.

ORIGINAL PAGE IS
OF POOR QUALITY

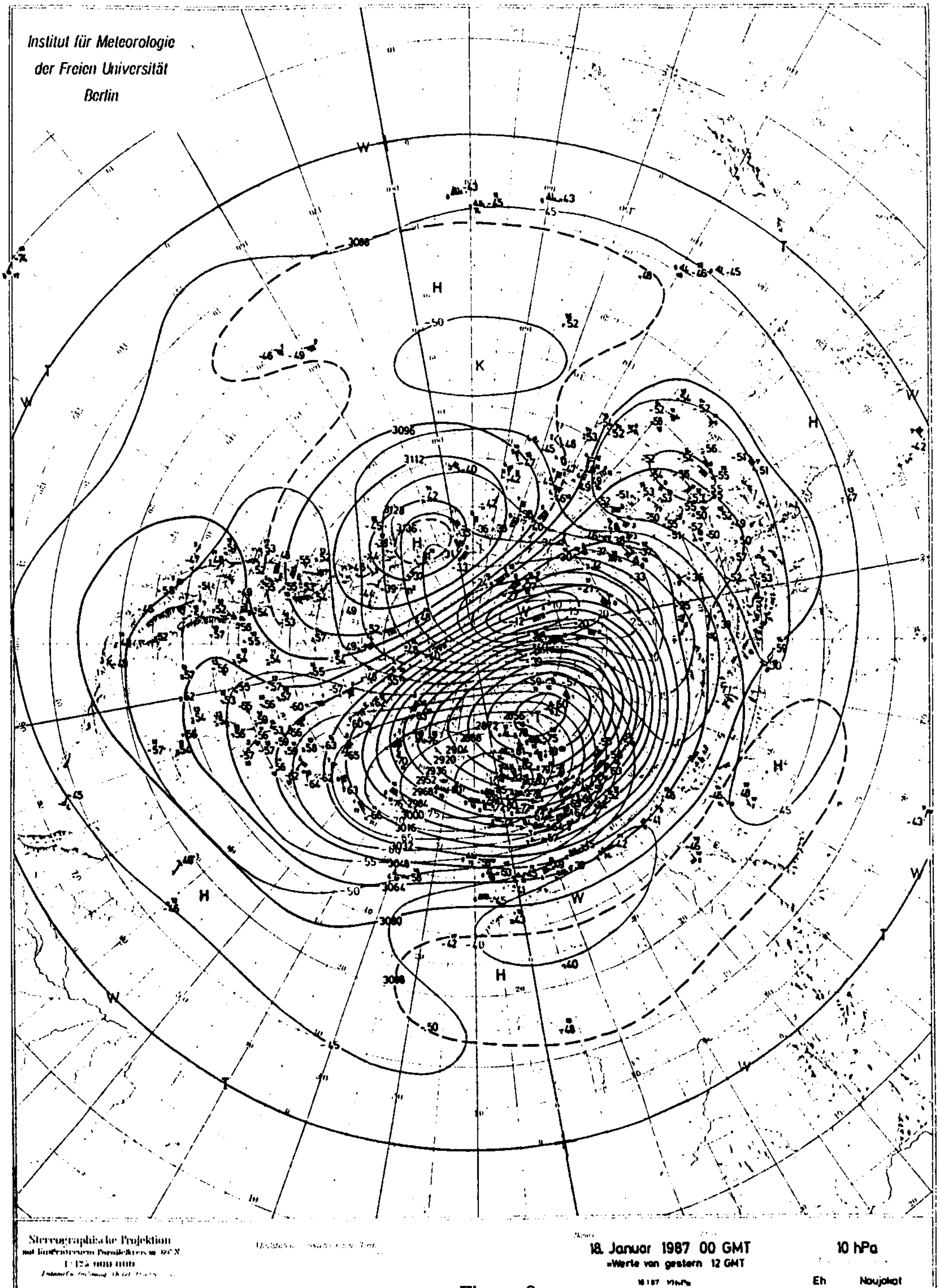

Figure 8.

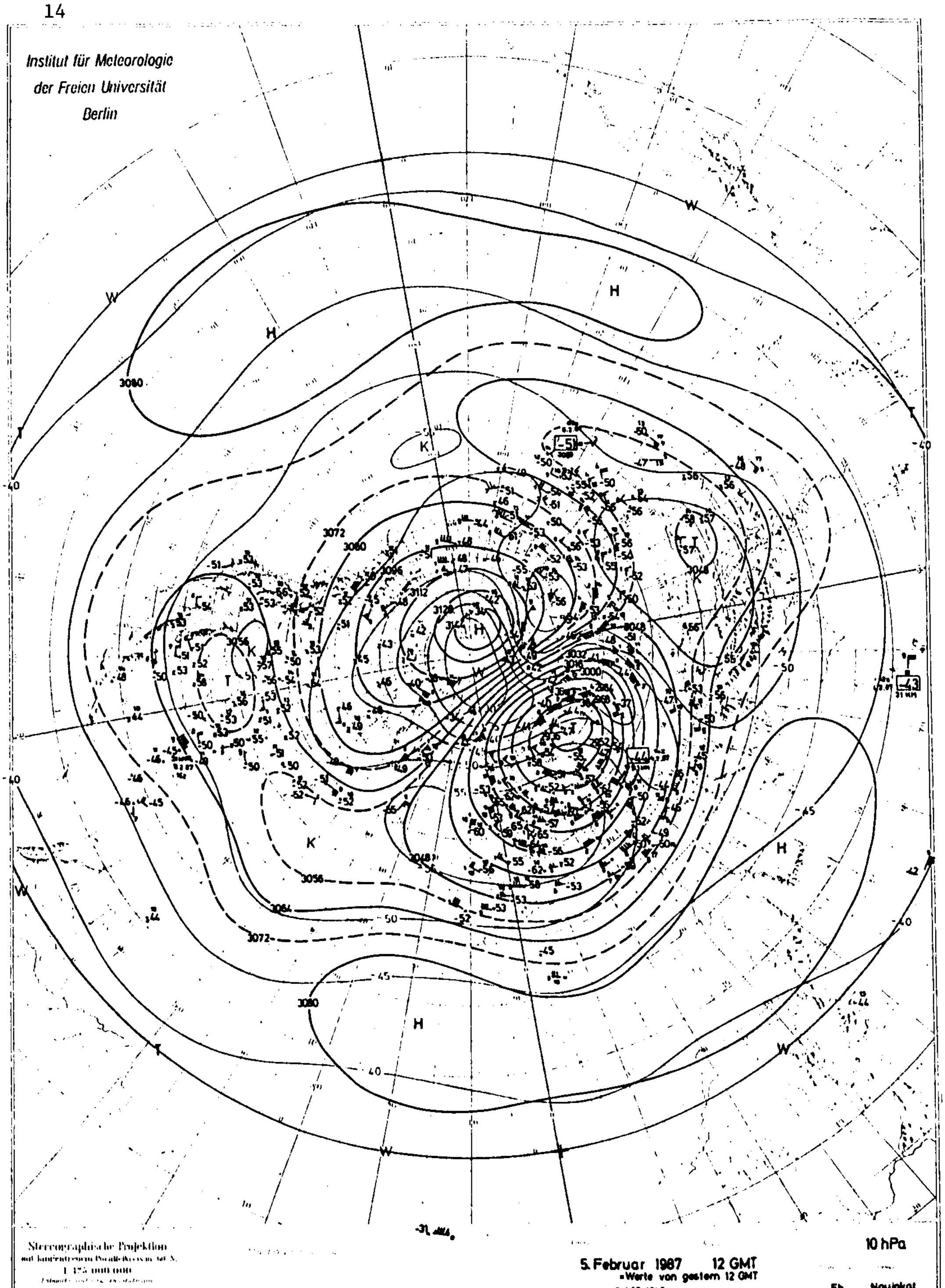

Figure 9.

ORIGINAL PAGE IS
OF POOR QUALITY

ORIGINAL PAGE IS OF POOR QUALITY

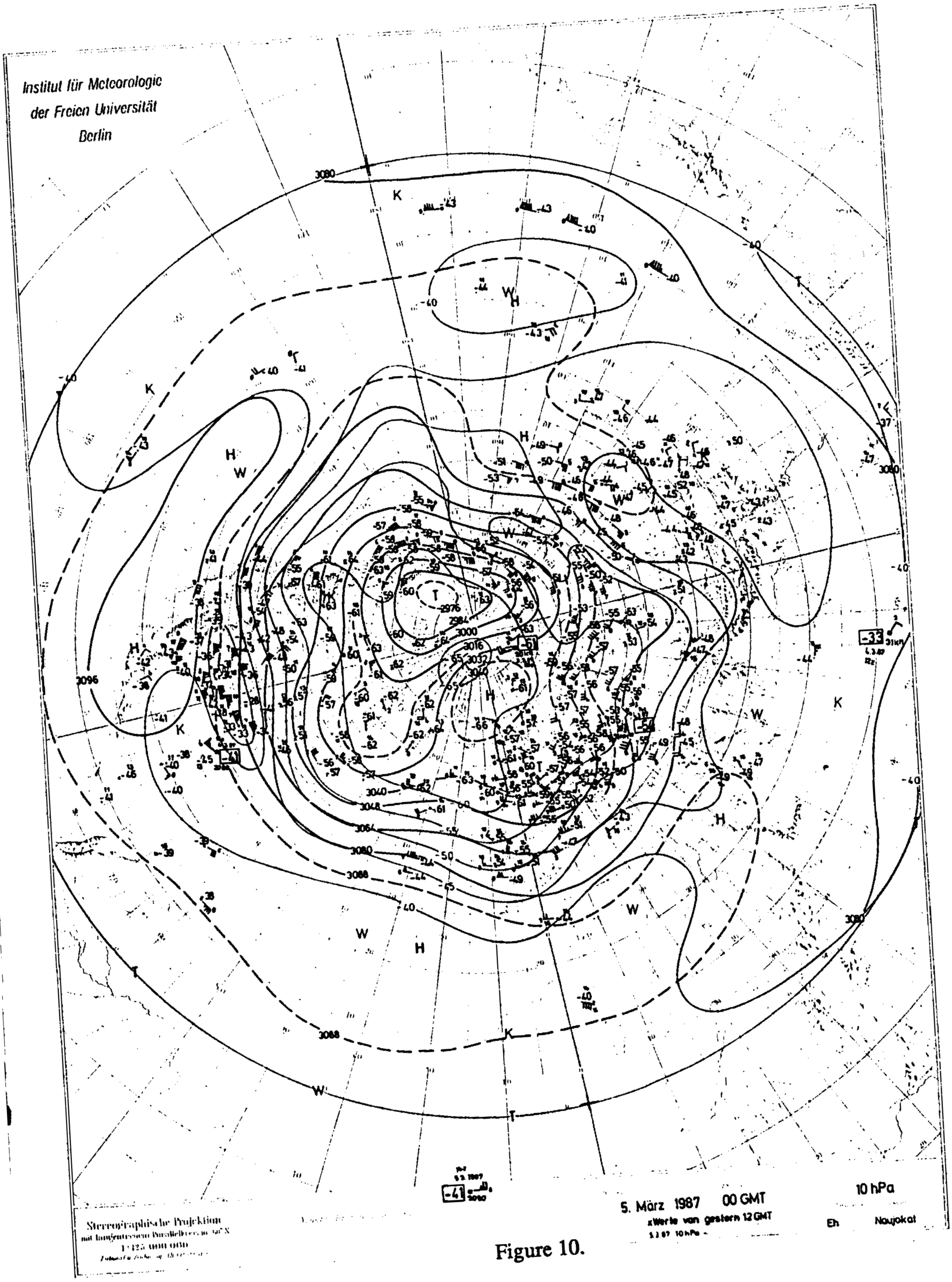

Figure 10.

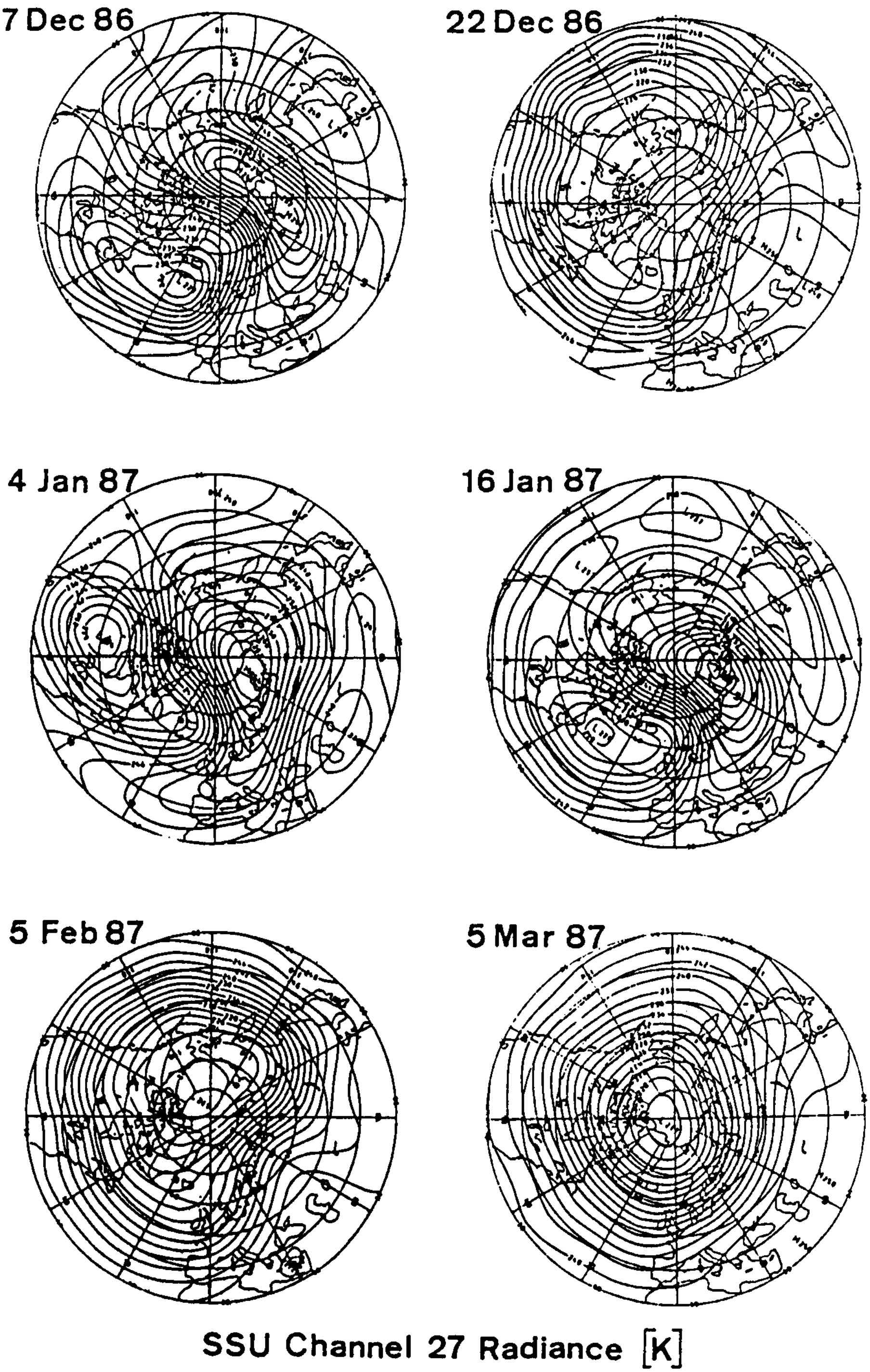

Figure 11. Charts of radiances (K) at channel 27 of the SSU, maximum weight around 1.7 hPa (courtesy Meteorological Office, Bracknell, UK).

ORIGINAL PAGE IS
OF POOR QUALITY

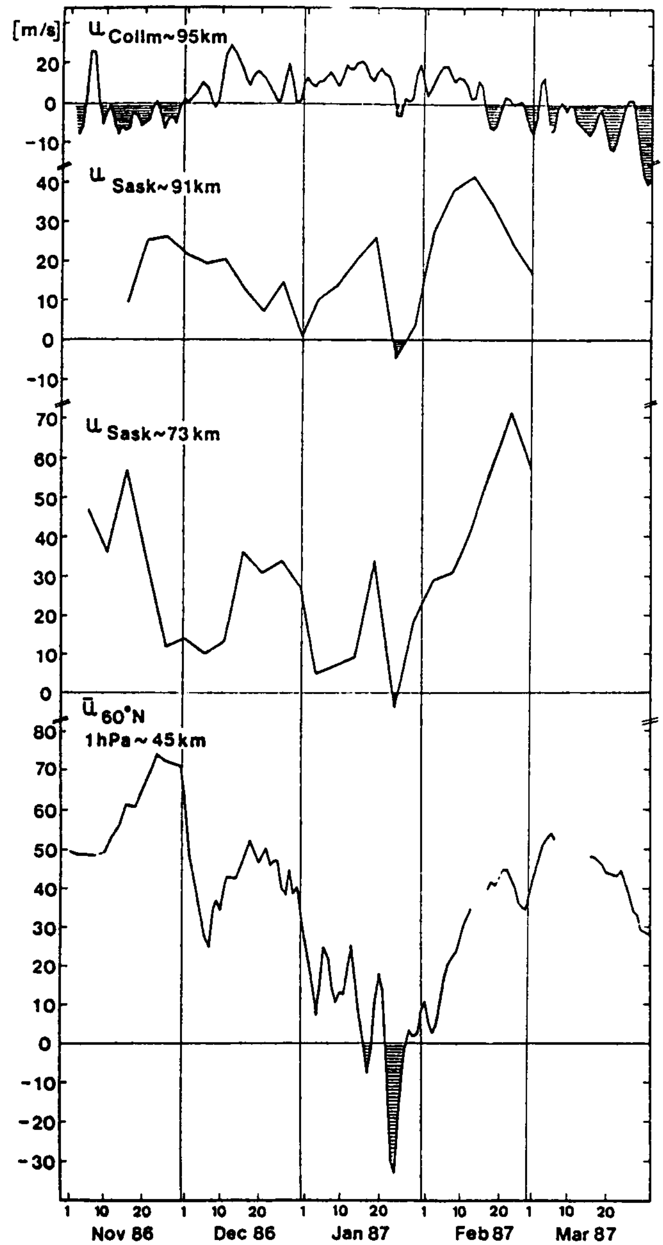

Figure 12. Upper stratospheric and mesospheric winds (m/s):

u_{SASK}: Zonal winds over Canada (52°N, 107°W) at 2 layers of 9 km thickness; tidally corrected 5-day means; measured by partial reflection radar (courtesy University of Saskatchewan, saskatoon, Canada)

u_{COLL}: Prevailing zonal winds over Central Europe (51°N, 13°E) around 95 km from low frequency drift measurements; 3-day running means with 1-2-1 weighting (courtesy Geophysical Observatory Coom, GDR)

$u_{60°N}$: Mean zonal wind at 60°N, 1 hPa (around 45 km) derived from SSU data (courtesy Meteorological Office, Bracknell, UK).

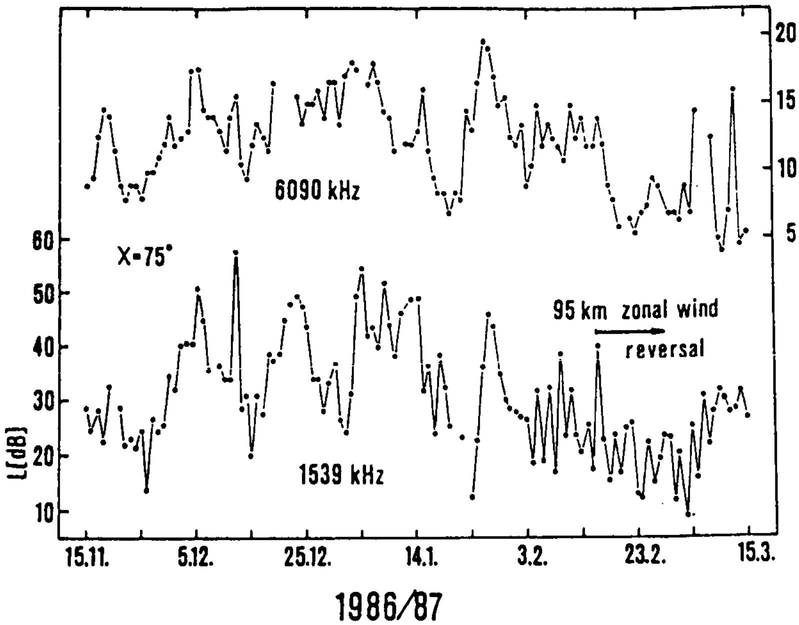

Figure 13. Radio-wave absorption (dB) over Central Europe (courtesy Geophysical Institute, Prague, CSSR).

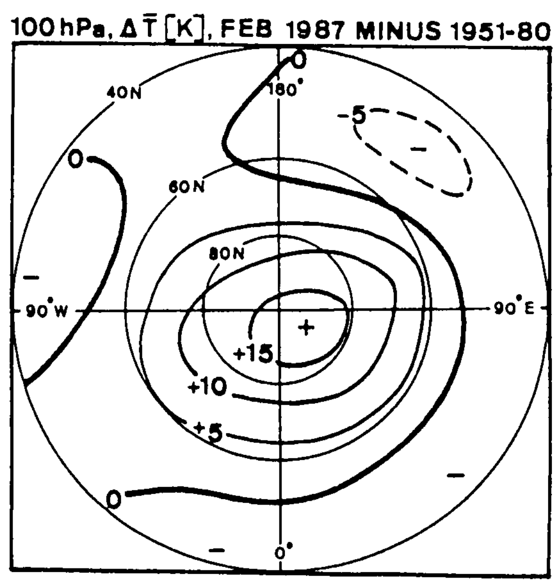

Figure 14. Monthly mean 100-hPa temperature deviations (K) of February 1987 from the 30-year average 1951-80.

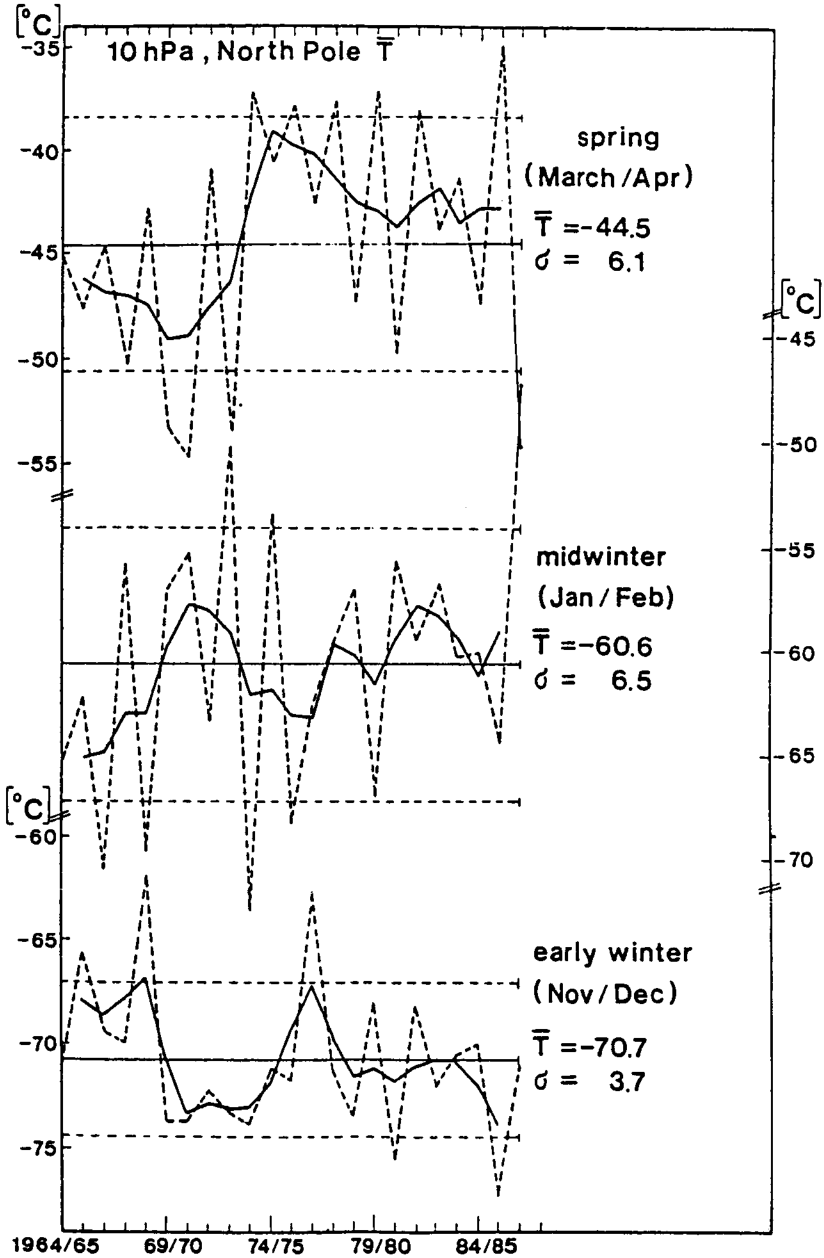

Figure 15. Monthly mean 10-hPa temperature (°C) at the North Pole in spring, midwinter, and early winter (- - - - single years, ------ 1-2-1 weighted mean).

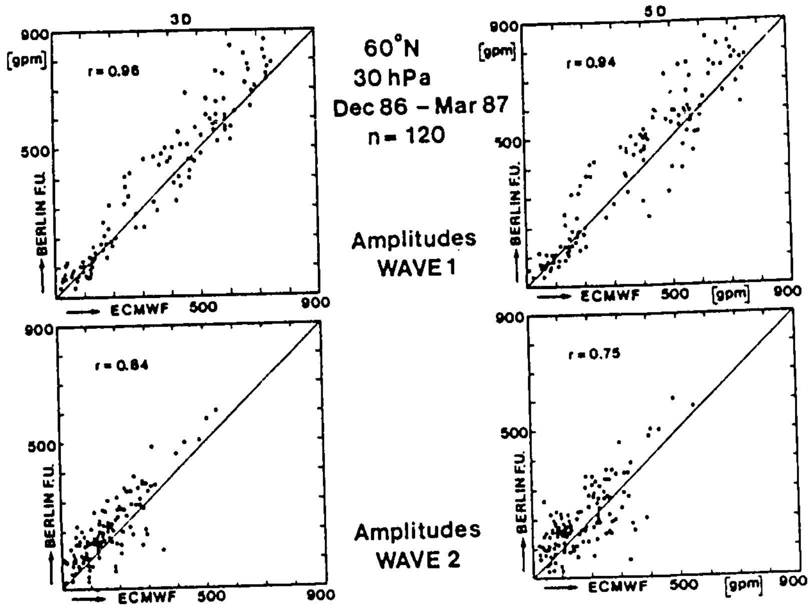

Figure 16. Comparison of amplitudes (m) of 30 hPa height waves 1 and 2 between the Berlin analyses and the ECMWF 3 and 5 day prognoses, respectively.

are used in all Figures displaying data of the 30- and 10-hPa levels. Figure 14 is based on 100-hPa mean charts which are regularly analyzed by means of the CLIMAT TEMP data.

Description of the Main Circulation Features of the Winter of 1986/87

Thirty-five years ago SCHERHAG (1952) first observed an "explosive" stratospheric warming. Such a major midwinter warming also occurred this winter and it was predestinated for these reasons: First, a warm event in the southern oscillation occurred in 1986, and VAN LOON and LABITZKE (1987) have shown that this usually leads to an intensification of the Aleutian anticyclone and wave-one type of major warming in January or February. Secondly, this winter belongs to the "easterly category" as defined by LABITZKE (1982); i.e., the quasi-biennial oscillation (QBO) was in the easterly phase, when there is a tendency for an enhanced development of height wave one already in early winter. This often leads to a major warming. Most recently, LABITZKE and VAN LOON (1987) have shown that this signal of the QBO in extratropical latitudes is stronger during the minimum of solar activity, which is happening now, than during solar maximum. In the following, the main circulation features of this winter will be described, dividing it into four periods:

1. *The cold early winter.* As in the year before (NAUJOKAT et al., 1986), there was no Canadian warming but the winter started with an extremely cold polar region in November. The strongest negative deviations from the long-term monthly mean were found over northern Canada (GEB and NAUJOKAT, 1986), but also the polar temperatures (Figure 1b) were well below the 20-year mean values during the whole of November, resulting in the lowest monthly mean temperature at the 30-hPa level since November 1955. The temperatures and radiances at the North Pole steadily decreased and the westerly wind increased until the end of November throughout the stratosphere (Figures 1a, 1b, 2b, 3, and 12).

2. *The minor warming.* At the end of November the planetary wave one intensified (Figures 2c and 2f) and for the first time a considerable amount of heat was transported northwards through 60° N at the 30-hPa level mainly by this wave (Figures 2d and 5). The temperatures and radiances at the North Pole (Figures 1a and 1b) started to rise, much faster in the upper than in the lower stratosphere. Although at 30 hPa the polar temperature remained below the daily 20-year means during most of December and also at 10 hPa the temperature gradient at high latitudes did not reverse (Figure 2e), an intense warming occurred in the upper stratosphere at the beginning of December. This is demonstrated by the radiance field of 7 December (Figure 11) which shows a large warm area over high latitudes and the cold air shifted far to the south. The corresponding 10-hPa chart (Figure 7) however, shows only a relatively weak warm region over northeastern Siberia and the centre of the cold air displaced from the pole towards Scandinavia. The undisturbed vortex persisted near the pole and that is also obvious in the pattern of the potential vorticity on this day (Figure 6). Accordingly, the mean zonal wind at 60° N was only slightly affected in the lower stratosphere (Figure 2b), but a strong weakening was observed at 1 hPa and also the mesospheric wind data -- at least as high as 73 km -- reflect the intensity of the warming (Figure 12).

Subsequent to this minor warming was the only time of the winter when the height wave two reached a considerable size, but already at the middle of December wave one again started to grow, concurrently with a strong weakening of wave two (Figures 2c and 2f). Although the temperatures/radiances at the pole returned to low values after the minor warming (Figure 1), they remained relatively warm over Siberia throughout the stratosphere. At 30 hPa strong positive height and temperature anomalies were observed over Asia (GEB and NAUJOKAT, 1987): an example from the upper stratosphere is given with the chart of radiances from 22 December (Figure 11).

3. *The major warming.* These conditions preceded one of the most intense midwinter warmings observed, as already shown in our first note on this event (LABITZKE et al., 1987). It

developed through several pulses and the first peak in the march of radiances and temperatures over the North Pole was already reached on 4 January (Figures 1a and 1b). It was the strongest one in the upper stratosphere and the radiance field of this day (Figure 11) shows a reversed temperature gradient over high latitudes, which also occurred briefly at the 10-hPa level (Figure 2e). The zonal wind at upper stratospheric and mesospheric heights was strongly affected -- although, it did not become easterly -- (Figure 12), and in the lower stratosphere the mean zonal wind at 60° N began to weaken, too (Figures 2b and 3). With the continuously strong planetary wave one (Figure 2f) the northward eddy heat flux steadily increased and reached its maximum of the winter around 17 January (Figures 2d and 5). This lead to a much higher temperature at the pole than at 60° N at the 10-hPa level (Figure 2e). Figure 4 shows the development of this last warming pulse by means of some selected rocketsonde and radiosonde ascents: the stratopause progressed downward from 13 to 18 January, the lower stratosphere warmed considerably, the upper part cooled, and at the final stage the stratosphere on 27 January was nearly isothermal.

The peak of the warming is shown by the 10-hPa map of 18 January (Figure 8) and the chart of radiances of 16 January (Figure 11). A strong southward momentum flux occurred (Figure 5), and a few days later the wind reversal was accomplished, i.e., an eastward flow dominated polewards of 60° N throughout the stratosphere and mesosphere (Figures 2b, 3, and 12). The criteria for a major warming were fulfilled, and the breakdown of the wintertime circulation was complete. The response of the lower ionosphere to these stratospheric processes is indicated by the behavior of the radio-wave absorption over central Europe (Figure 13). While the absorption was relatively high during the first half of the winter, it became low in the second half of January.

At the beginning of February the warm centre and the anticyclone reached the North Pole at the 10-hPa level (Figure 9) and an area of low potential vorticity was found over high latitudes (Figure 6). In the following period the warming became fully effective down to the lowest stratospheric levels and even to the troposphere (GEB and NAUJOKAT, 1987). At 100 hPa the monthly mean temperatures of February were more than 15 degrees above the 30-year mean (Figure 14). The intensity of this major warming can also be seen in Figure 15, where the 10-hPa temperatures at the North Pole have been averaged for the winter and spring months since 1964/65.

4. *The late winter cooling*. At the same time as the warming penetrated downward, a pronounced late winter cooling began in the upper stratosphere (Figure 1a). The radiance field of 5 February (Figure 11) -- the same day as the warm centre reached the pole in the lower stratosphere -- shows a cold region in polar latitudes. The upper stratospheric and mesospheric winds became westerly again (Figure 12), while at the lower levels the mean zonal wind at 60° N was easterly during nearly the whole of February (Figures 2b and 3), together with a reversed temperature gradient at high latitudes (Figure 2e). The late winter cooling did not penetrate to these levels until the end of February, but on 5 March the charts of the 10-hPa level (Figure 10) as well as the radiances (Figure 11) show a pronounced cold centre over the Pole. At that time the spring reversal at the mesopause was already accomplished (Figure 12) and the lower ionosphere responded with a broad minimum of radio-wave absorption (Figure 13); but in the stratosphere the re-established vortex persisted during March. The mean zonal winds remained westerly (Figure 2b and 12) and the final transition to the summer circulation did not occur until the middle of May, i.e., an extremely late final warming was observed which resulted in nearly the lowest mean temperature for March and April at 110 hPa since 1965 (Figure 15).

Comparison Between ECMWF-Prognoses and Berlin Analyses

The daily transmitted 3- and 5-day forecasts of the 30-hPa heights were again of great help for the preparation of the STRATALERT messages. They predicted well the amplification of height wave one and afterwards of wave two in connection with the minor warming in December and also the three peaks of wave one during the major warming in January which was followed by a rapid decrease of the planetary wave activity during the breakdown of the vortex in February (see Figure 2f). Comparing the amplitudes at 60° N as analyzed in Berlin and as forecast by the ECMWF (Figure 16), the agreement is very good for wave one at both time scales, even better than in the year before. As regards wave two, which was weak during most of the winter, the correlations are also not bad and similar to those in the year before. There is still a tendency in the forecasts to underestimate the wave amplitudes.

Acknowledgments

For watching the middle atmosphere wintertime circulation, preparing the daily STRATALERT and the GEOALERT messages, and providing material for this report we should like to thank the groups mention in the Introduction. Special thanks go to A. O'Neill, Bracknell, E. Klinker, Reading, A. H. Manson, Saskatoon, R. Schminder, Collm, A. Hauchecorne, Verrieres-le-Buisson, and J. Lastovicka, Praha. Further, we should like to thank the members of the Stratospheric Research Group, F. U.Berlin for their untiring effort and assistance and thank the Deutscher Wetterdienst for arranging the direct transfer of the ECMWF prognoses.

References

Geb, M., and B. Naujokat , 1986/87: Nordhemisphärischer Klimabericht zum November 1986 Dezember 1986, and February 1987. *Beilagen zur Berliner Wetterkarte, KNH XI86, KNH XII/86*, and *KNH II/87.*

Labitzke, K., 1982: On the interannual variability of the middle stratosphere during the northern winters. *J. Meteor. Soc., Japan, 60*, 124-139.

Labitzke, K., R. Lenschow, B. Naujokat, K. Petzoldt, and R.-C. Wohlfart, 1987: First note on the major stratospheric warming in January 1987. *Beilage zur Berliner Wetterkarte, SO 5/87.*

Labitzke, K., and H. van Loon, 1987: Associations between the 11-year solar cycle, the QBO, and the atmosphere. Part I: The troposphere and stratosphere on the northern hemisphere in winter. Submitted to *J. Atmos. Terr. Phys.*

Naujokat, B., K. Labitzke, R. Lenschow, K. Petzoldt, and R.-C. Wohlfart, 1986: The fourth winter of MAP-DYNAMICS, 1985/86: A cold winter with two minor warmings and a major final warming. *Beilage zur Berliner Wetterkarte, SO 13/86.*

Scherhag, R., 1952: Die explosionsartige Stratosphärenerwärmung des Spätwinters 1951/52, *Ber, d, DWD US -Zone, 6*, 38, S.51.

Van Loon, H., and K. Labitzke, 1987: The Southern Oscillation. Part V: The anomalies in the lower stratosphere of the northern hemisphere in winter and a comparison with the quasi-biennial oscillation, *Mon. Wea. Rev., 115*, 357.

APPENDIX 4

GLOBUS NO_x

J. P. Pommereau, GLOBUS Coordinator

The goal of this project is to provide a coherent set of data on nitrogen oxides in order to evaluate their contributions to the general stratospheric photochemistry. Coordinated observations of nitrogen species together with other pertinent parameters like interfering species, temperature and solar fluxes, were performed during a field campaign held in September 1985 at Aire sur l'Adour in France. Ground-based, balloon and satellite data have been processed and were discussed during two workshops, at Toulouse in July 1986, and Vancouver in August 1987. Experimental results and incertitudes have been discussed and a first series of nine contributions was presented during the IUGG General Assembly in Vancouver. Corresponding papers will be submitted for publication by the end of 1987 and will be followed in 1988 by several other experimental publications on subjects which need still more investigation. Analysis and interpretation of the global results together with modelers will begin early in 1988.

Presentation of GLOBUS NO_x Results at Symposium on Middle Atmosphere Aeronomy and Electrodynamics

IUGG Vancouver, August 1987

J. P. Pommereau, F. Goutail, N. Iwagami, K. Shibazaki, T. Ogawa, J. Lenoble, and P. C. Simon, Comparison between NO_2 visible absorption measurements from balloon and satellite during GLOBUS NO_x

D. Robbins, P. Aimedieu, J. Pelon, G. Megie, N. Iwagami, and T. Ogawa, Comparison of ozone measurements in the stratosphere during GLOBUS NO_x

J. de la Noe, T.Ogawa, and P. Marche, Comparison of stratospheric and mesospheric ozone profiles obtained by ground based and satellite observations

P. Fabian, G. Flentje, B. C. Kruger, and G. Wang, Night day transition of NO_x radicals measured in the midlatitude stratosphere

F. Goutail, and J. P. Pommereau, An advanced UV visible spectrometer for stratospheric composition measurements from balloons

W. A. Matthews, Y. Kondo, and P. Fabian, Nitric oxide profiles measured in situ during GLOBUS NO_x

J. P. Naudet, P. Rigaud, and D. Huguenin, Altitude distributions of O_3, NO_2, and NO_3 at night during GLOBUS NO_x

H. K. Roscoe, Oxides of nitrogen measured during GLOBUS NO_x

APPENDIX 5

MAC/SINE: A Report to the MAP Steering Committee

E. V. Thrane, Project Scientist

Middle Atmosphere Cooperation/Summer in Northern Europe (MAC/SINE)

The MAC/SINE campaign was carried out during the period 7 through 19 July 1987. The primary purpose of the project was to study dynamical processes, winds, waves and turbulence in the high-latitude summer middle atmosphere. Measurements were carried out using a combination of instrumented sounding rockets, meteorological rockets, and ground-based radar and lidar techniques. The ground-based techniques provided extensive series of synoptic measurements, whereas the rocket program comprised regular launches of met-rockets as well as launches of 6 "salvos" constructed to study specific phenomena.

The observational program was very successful, and a preliminary review of the data shows that the summer, high-latitude mesosphere is a complex and variable medium. It is hoped that the results will throw new light on a number of interesting specific phenomena as well as increase our understanding of the general summer circulation.

Rocket and ground-based instrumentation. Tables 1 and 2 show, respectively, the rocket types launched from Andøya Rocket Range and as part of the USSR program. No report has yet been received concerning the results from the USSR. Table 3 lists the ground-based instrumentation in operation during SINE. As indicated in the Table, some of these instruments provided real-time information and were used as diagnostic tools to monitor and determine the launch conditions for the salvos.

Observations. The ground-based measurements were, as far as possible, made continuously throughout the whole campaign period. The mode of operation is indicated in Table 3. More detailed information on some of the most important instruments is given below.

The SOUSY radar provided a very extensive set of measurements of winds, waves and turbulence, mainly between 80 and 90 km where persistent echoes were normally observed from early morning to the afternoon hours.

The PRE radar observed drifts in the D region throughout the campaign, and detailed measurements of ordinary and extraordinary echo amplitudes were made during all rocket launches. In striking contrast to winter measurements very few echoes were observed below 80 km.

The EISCAT VHF radar was operated successfully for nearly 60 hours as part of the campaign. The normal operation times were from 09-13 UT on Mondays, Wednesdays and Fridays. The measurements will provide information on vertical winds, electron density and possibly ion composition. Of particular interest was the observation of very intense echoes from a very thin layer near the mesopause.

The Bonn University Lidar. Successful observations of the thermospheric sodium layer were made during the last part of the campaign and these were extended for several weeks beyond the end of SINE. Very interesting results were obtained on the fine structure of the sodium layer, its total density and diurnal variation.

Table 1
Scientific rockets from ARR

Type	# Of Systems	Param. Observed	Apogee	Institution	Scientist
FS	30	Density, Wind	120	U Bonn	U von Zahn W Meyer
Chaff	30	Wind	95	U Bonn/MPAe	H U Widdel/ U von Zahn
Super Arcas	4	Ioniz. Structure	96	Utah State Univ.	J Ulwick

Table 2
Scientific rockets of the USSR

Type	Approx. # of systems	Location	Launch Times	Parameters Observed
Unknown	44	Northern Norwegian Sea	02, 06, 14, 18 LT ± 2 Hrs. 20 - 30 June	Unknown
Unknown	8	50°N. 20°W. Atlantic Ocean	04, 14 LT ± 2 Hrs. 13 - 16 July	Unknown
Unknown	2	On Request	On Request	Unknown
M-100 B	12	Heiss Isl.	Wednesdays, Saturdays	Temperature below 75 - 80 km. winds below
M-100 B	6	Volgograd	Wednesdays	80 - 85 km, e^- below 85 - 100 km, ε between 75 and 80 km

Table 3 (Rev. 9 June 87)
Ground-based experiments in MAC/SINE

EXPERIMENT	OBSERVED PARAMETERS	LOCATION	REAL TIME	OPERATION
Partial Reflection	e^- density turbulence	Ramfjordmoen	N Y	CD
PRE Drift	winds	Ramfjordmoen	Y	C
Partial Reflection	turbulence	Volgograd	N	C
SOUSY VHF Radar	turbulence winds	Bleik	Y N	CD after 15 June
EISCAT	e^- density, λ winds	Ramfjordmoen	N Y	B
MS-Radar	winds	Saskatoon	N	C
GLOBMET	winds	USSR (7x)	N	C
Meteor Radar	winds	Volgograd	N	C
HF-Circuit	propagation conditions	Andenes-Alta	N	C
Ionosondes	ionospheric conditions	Andenes, Ramfjordmoen	Y	A
A1-Absorption	Abs. 2.2 MHz	Volgograd	N	C
Riometers	absorption	Andenes, Finland (9x), Kiruna (KGI), Ramfjordmoen	Y	C
Magnetometers	geomagnetic conditions	Andenes, Finland (NX), Kiruna (KGI), Ramfjordmoen	Y	C
UB Lidar	NA-density density	Andenes	Y	CS, after 28 June
UI Lidar	NA-density, winds	Longyearbyen	N	CS
CNRS Lidars	density, temperature	Skibotn, on ship	N	CS
Fabry-Perot Triple Etalon	winds	Kiruna (KGI)	N	?CS?

A Every 20 minutes
B On regular launch days from 9-13 UT; 9-19 UT possible from 29 June
C Continuous
CD Continuous during CountDowns
CS Continuous when Clear Sky

The sequence of rocket launches for Andøya Rocket Range is given in Table 4. Note that the rockets in the six salvos are grouped together.

As the Table shows, the regular met-rocket (Viper 3A Falling Sphere) launches were carried out on Mondays, Wednesdays and Fridays at or near 11:00 UT.

Three Chaff salvos were launched to study detailed wind and wave structure in the mesosphere. These typically contained 4 chaff rockets and 2 falling spheres.

The Turbulence/Gravity Wave salvo was launched on 14 July during conditions with very strong and variable echoes observed with the 50 MHz SOUSY and the 2.75 MHz PRE radars. The radars indicated strong winds and turbulence above 80 km, and the electron probe on the first and second Super-Arcas payloads showed interesting detailed structures in the mesopause region. The third Super-Arcas was launched as a reference during conditions with no significant radar echoes.

The EISCAT salvo was launched on 15 July, using the EISCAT VHF radar and the SOUSY as primary diagnostic tools. During the salvo strong echoes were observed from layers near the mesopause on both radars, and exceptionally strong structures were observed at this level by the Super-Arcas electron probe. Sodium lidar observations were also made during this salvo.

The Sodium/Chaff salvo was launched before midnight on 15 July during a period with magnetic activity and particle precipitation. The main diagnostic tool was the Bonn University sodium lidar, but SOUSY, PRE and the ionosondes were also in operation. Development of sudden sodium layers were observed during this salvo. The chaff rockets launched into these layers should yield *in situ* information on the dynamical structure of the mesopause region during such conditions.

Conclusion. This very preliminary overview of the campaign only mentions some of the experiments, but indicates that the project MAC/SINE was very successful and that the data analysis may be expected to yield new important information on the high-latitude summer middle atmosphere.

Table 4
Rocket launches during MAC/SINE

Launch time (UT):			Remarks:
S-F1	10/6	13:40	116-20 km (collapse: 30 km); noisy AGC above 70 km.
S-F2	12/6	11:00	115-22 km (collapse: 28 km); noisy AGC above 77 km.
S-F3	15/6	11:24	109-28 km (collapse: 29 km); noisy AGC above 77 km; spikes in AGC below.
S-C1/H	15/6	11:57	Booster failure; missing ejection charge.
S-F4	17/6	11:03	115-27 km (collapse: 29 km); noisy AGC above 75 km.
S-F5	19/6	11:05	113-26 km (collapse: 28 km); noisy AGC above 80 km.
S-F6	22/6	11:29	114-27 km (collapse: 29 km); noisy AGC above 70 km; spikes in AGC below
S-C2/H	22/6	12:30	83-71 km; O. K.
S-C3/H	22/6	13:11	Dart failure; no ejection of foils.
Chaff salvo no. 1:			
S-F7	24/6	11:00	105-27 km (collapse: 28 km); noisy AGC above 70 km; spikes in AGC below.
S-C4/L	24/6	11:20	93-82 km; O. K.
S-C5/L	24/6	11:53	94-82 km; O. K.
S-C6/L	24/6	12:25	Dart failure; no ejection of foils.
S-C7/L	24/6	12:40	97-61 km; O. K.
S-C8/L	24/6	13:33	99-84 km; O. K.
S-FB	24/6	13:58	112-26 km (collapse: 28 km); noisy AGC above 75 km; spikes in AGC below
Chaff salvo no. 2:			
S-F9	26/6	11:00	115-26 km (collapse: 28 km); some spikes in AGC down to collapse altitude.
S-C9/L	26/6	11:27	95-77 km; O. K.
S-C10/H	26/6	12:01	Dart failure; no ejection of foils.
S-C11/L	26/6	12:44	96-72 km; O. K.
S-C12/H	26/6	13:36	86-71 km; O. K.
S-F10	26/6	14:12	114-26 km (collapse: 28 km) noisy AGC above 70 km; spikes in AGC below.
S-F11	29/6	11:06	112-26 km (collapse: 28 km); noisy AGC above 75 km; spikes in AGC below.
Chaff salvo no. 3:			
S-F12	1/7	21:08	112-30 km (collapse: n.a.);
S-C13/L	1/7	21:28	95-71 km; O. K.
S-C14/H	1/7	22:15	82-62 km; O. K.
S-F13	1/7	23:05	113-28 km (collapse: 29 km);
S-C15/L	1/7	23:34	96-88 km; O. K.
S-C16/H	1/7	23:49	83-67 km; O. K.

Table 4 (Continued)

S-F14	3/7	11:00	112-26 km (collapse: 28 km);
S-F15	6/7	12:40	105-26 km (collapse: 29 km);
S-F16	8/7	13:00	107-26 km (collapse: 29 km);
S-F17	10/7	12:12	107-26 km (collapse: 28 km);
S-F18	13/7	19:55	106-27 km (collapse: 51 km);
<u>Turbulence / gravity wave salvo:</u>			
S-SA1/L	14/7	08:00	95-0 km; Success.
S-F19	14/7	08:11	108-37 km (collapse: 40 km);
S-F20	14/7	08:32	115-30 km (collapse: n.a.);
S-C17/L	14/7	08:52	95-75 km; O. K.
S-SA2/H	14/7	09:29	96-0 km; Success.
S-C18/L	14/7	09:43	96-78 km; Lost track at T + 11 min, re-acquired separated cloud at T + 16 min. O. K.
S-C19/H	14/7	10:19	80-63 km; O. K.
S-F21	14/7	11:02	116-28 km (collapse: 34 km);
S-C20/L	14/7	11:30	Dart failure; no ejection of foils.
S-C21/L	14/7	12:03	94-77 km; O. K.
S-SA3H	14/7	12:55	93-0 km; Success.
S-C22/L	14/7	13:07	Dart filure; no ejection of foils.
<u>Eiscat salvo:</u>			
S-SA4/L	15/7	12:32	98-0 km; Success.
S-F22	15/7	12:46	107-30 km (collapse: n.a.);
S-C23/L	15/7	13:06	97-83 km; O. K.
<u>Sodium / chaff salvo:</u>			
S-C24/L	15/7	20:30	95-78 km; O. K.
S-F23	15/7	21:01	117-45 km (collapse: n.a.);
S-C25/L	15/7	21:17	97-84 km; O. K.
S-F24	15/7	21:43	112-38 km (collapse: n.a.)
S-C26/L	15/7	22:01	96-83 km; O. K.
S-C27/L	15/7	22:30	95-81 km; O. K.
S-C28/L	15/7	22:54	91-81 km; O. K.

S-F25	17/7	11:00	111-27 km (collapse: 29 km);
S-F26	19/7	11:07	115-85 km; Failure.
S-F27	19/7	11:21	111-25 km (collapse: 28 km);

APPENDIX 6

MIDDLE ATMOSPHERE ELECTRODYNAMICS (MAE)

R. A. Goldberg, Coordinator

Middle Atmosphere Electrodynamics has been quite active during the last two years. Rocket and balloon programs conducted or planned are listed in Table 1. In addition, some balloon activity has also been conducted in India, as reported by Dr. Gupta at the IAGA Division 2 meeting on MAE on August 11, 1987. New findings include evidence for modification of electric fields in noctilucent clouds, a theoretical explanation for large horizontal mesospheric fields, and a new technique to monitor global thunderstorm activity using measurement of Schumann resonances. In addition, balloon measurements have identified atmospheric neutral waves through measurement of horizontal electric fields in the stratosphere, and rockets have measured turbulence and waves in the mesosphere through the measurements of ion and electron densities and their gradients.

Much activity and discussion has also concerned the need and for a geoelectric index. The American Geophysical Union, through its Committee on Atmospheric and Space Electricity (CASE) has promoted this subject through a special session at the AGU Fall meeting in San Francisco in December 1986. Their newsletter publication EOS also featured an article on this topic by Holzworth and Volland. The IAGA II Working Group on MAE also pursues this question actively.

It would appear that this field is now expanding as new discoveries, results, and theories place it on a stronger basis, thereby promoting new and more extensive activities and programs dedicated to the subject.

Table 1. Atmosphere electrodynamics recent rocket and balloon activities.

*	1985	Spring	Mesospheric Turbulence Program Poker Flat, Alaska
		Summer/Fall	Thunderstorm Program Wallops Island, Virginia
*	1986	Summer	Noctilucent Cloud Study Kiruna, Sweden
*	1987	Summer	Thunderstorm Program - Wave Induced Particle Precipitation Program (WIPP) Wallops Island, Virginia MAC/SINE - Scandinavia
			UPCOMING PROGRAMS
*	1987	Fall	MAC-Epsilon Andoya, Norway
*	1988	Summer	Thunderstorm Program Wallops Island, Virginia
*	1990	Summer	SUPERCAMP Thule, Greenland

APPENDIX 7

NEW INTERNATIONAL EQUATORIAL OBSERVATORY (NIEO)

S. Kato and S. Fukao
RASC, Kyoto University

A new development has taken place since last year 1986 towards the promotion of this project. RASC submitted an official request to the Government on funding the equatorial MU radar which is the central facility of NIEO.

In July 1987, a group of five Japanese scientists and three engineers visited Indonesia for a feasibility study of the site in Pontianak for the radar construction in West Kalimantan. They surveyed the land condition in cooperation with LAPAN (Indonesian Aeronautics and Space Agency) officials. While no unfavorable condition was found as to radio noise in the 45-50 MHz range, it was concluded that further details and precise investigations are required, especially about the land foundation and the soil properties. This survey was supported by the Nissan Science Foundation. Besides the survey, Prof. S. Kato, head of the group, gave a lecture on NIEO at Tanjungpura University before an audience of a few hundred students and faculty. The University has an Electrical Engineering faculty which will be useful in the radar operation in the future. Also, the Governor of West Kalimantan and the Mayor of Pontianak expressed strong support of NIEO.

At LAPAN's Headquarters in Jakarta, discussion was held, based on our proposal as shown below, by Prof. Kato and Dr. Fukao of the group and by Mr. Soebroto, Chairman, and Mr. Soegijo, Head of the Aerospace Research Center of LAPAN, reaching an agreement to promote strong the project. Mr. Soebroto will make the utmost effort to obtain support among other high government officials in Indonesia.

A pamphlet both in English and Japanese on the equatorial radar was published in June and is available upon request. It is concluded at present that the NIEO project has a promising future whilst there are many steps to be taken before the initiation.

Proposal on the Establishment of Equatorial Observatory

The atmosphere plays an important role in many ways in human life. The lowest part of the atmosphere, called the troposphere, greatly influences our life through weather and climate. Above the troposphere, roughly from 10 to 50 km in height, lies the stratosphere. The activity of our life has now expanded to the lower stratosphere as seen in busy air traffic. It is the stratosphere which protects all life on the ground by preventing excessive solar ultraviolet radiation from reaching the surface. Beyond the stratosphere the atmosphere begins to be ionized by solar ultraviolet and X-ray radiation. The ionosphere is the region of the atmosphere where the ionization is very abundant, say above 100 km to 1,000 km in height. The ionosphere behaves as an important mirror of radio waves utilized for over-the-horizon telecommunications among distant places on the spherical earth. The region between the stratosphere and the ionosphere is called the mesosphere, which, though extremely rarefied, is full of interesting atmospheric dynamical phenomena.

It has been fairly recently recognized that the whole atmosphere, from the troposphere to the ionosphere and beyond, is closely coupled, with effects generated in one region often propagating to another region. When the atmosphere moves on a global scale beyond territorial boundaries, it transmits energy and momentum in the form of atmospheric waves from near the ground up to the ionosphere. Also, electromagnetic force influences from outer space strongly affect the ionosphere and probably the atmosphere further down.

In order to forecast more correctly daily weather and climate over longer time scales, it is essential to observe the atmosphere not only globally over the earth's surface but also vertically well beyond the troposphere. Better resolution in time and space is also required in these observations.

The equatorial region is the location of maximum solar energy input to the atmosphere. One of the three key equatorial regions is the Indonesian Archipelago; equatorial Africa and the Amazon are the other two districts. The equatorial region, in general, is also abundant in atmospheric disturbances (particularly in the regions of the large equatorial land masses), which are able to travel upwards more easily at the equator than in other latitudes, presenting close coupling of the atmosphere over an extended height region. However, our present understanding of this important equatorial atmosphere remains rudimentary because of a lack of suitable observations. Thus, it is scientifically very significant and practically beneficial to conduct extensive observations there.

Recently it has been well established that the MST (mesosphere-stratosphere-troposphere) radar is a novel and very powerful tool for observing atmospheric motions. Such a facility, together with other more conventional facilities, is necessary for adequate observations. In the Asian sector, Kyoto in Japan, Chung-Li in Taiwan, and Adelaide in Australia have MST or ST (stratosphere-troposphere) radars, presenting an excellent latitude alignment for cooperative atmospheric observations. Considering the close cooperation among these existing observatories, Borneo would be a very strong candidate for an equatorial observatory site along the same longitude.

For the past few years, LAPAN has strongly promoted the establishment of an equatorial observatory, now in the international planning stage, at Pontianak Kalimantan (Borneo). The main facility of this observatory is a giant radar for observing the atmosphere in motion. The radar is similar in design, but larger in size, than the MU radar at Kyoto University in Japan. The observatory would be important not only in science, but also profitable in other ways for Indonesia. Data obtained at the observatory would be significant, complementing those obtained by satellites, for the forecast of regional weather and also for the study of global climate change. Note that some global anomalous weather conditions, such as those by El Nino, are very sensitive to the atmospheric conditions in this equatorial region. Various advanced techniques used at the facility would be effectively used for educating local people in telecommunications, electronics and computer usage.

This observatory would symbolize Indonesia as a world center in the research of the equatorial atmosphere. It is expected that the observatory will contribute tremendously to the development of tropical meteorology, aeronomy and atmospheric remote sensing.

Although the observatory construction and maintenance are expected to be funded by Japan, the USA and others, the overall participation of Indonesia as the host is essential to make this plan successful.

APPENDIX 8

SUPER CAMP
A Cold Arctic Mesopause Project Within the Middle Atmosphere Program

E. Kopp, R. C. Philbrick, G. E. Thomas, G. Witt, and R. A. Goldberg

Program Summary

In 1981 the Cold Arctic Mesopause Project (CAMP) was accepted to be one of the first projects of the Middle Atmosphere Program (MAP) [Björn, 1982]. The aim of CAMP was to study relevant physical and chemical parameters for the formation of noctilucent clouds (NLC). The project was stimulated by the results obtained in an earlier European NLC campaign in summer 1978 with rocket launching from Kiruna [Björn et al., 1985] .

The main activities of CAMP consisted of several rocket launchings from Kiruna in summer 1982 [Björn, 1984; Kopp et al., 1985a]. This rocket campaign proved that in summer mesospheric temperatures at high latitudes are as low as 110°K [Philbrick et al., 1984].

In summer 1982, a continuous operation of the ultraviolet spectrometer experiment (UVS) was begun on the Solar Mesospheric Explorer (SME) spacecraft [Thomas, 1984]. This experiment provided a series of measurements over five summer seasons [Thomas and McKay, 1985]. They established that thin polar mesospheric clouds (PMC) are regularly observed over the summer polar region at an altitude of 82-88 km. The upper limit of particle diameters of PMC ice particles from the UVS results is 0.14 microns and the probability of PMC appearance in July is close to 40% at 65-70°N, increasing with latitude to values as high as 80% around 80°N [Olivero and Thomas, 1986].

Ground-based radar experiments at high latitudes have recently analyzed the wind field and tidal waves in summer. In contrast to a normal winter situation, gravity waves of tropospheric origin can penetrate through the stratosphere up into the mesosphere. The existence and persistence of mesospheric ice clouds (PMC) over extended regions around the geographic pole is believed to be connected to the special dynamics and wave dissipation in the summer middle atmosphere.

Ice particles which are connected to PMC and NLC occur at altitudes 82-92 km in the summer polar mesosphere. Their size and concentration are expected to vary with altitude and latitude. Electron attachment and positive ion nucleation lead to different charges on ice aggregates. It is thus expected, that horizontal and vertical transport by winds and gravity introduces further charge separation with the result that PMC and NLC can act as horizontal and/or vertical E-field generators.

The lack of experimental data at latitudes above 70°N in summer -- data which are needed to understand and model the physics and chemistry of the formation of PMCs and NLCs -- provided the main reason for CAMP scientists to propose an international research campaign named SUPER CAMP [Kopp et al., 1985b]. These measurements together with additional experiments in places south of 70°N will give the necessary results to determine latitudinal variability of vertical transport, wave dissipation, and its implications on densities of minor constituents (H_2O, odd hydrogen, O_3, O, NO, etc.).

References

Björn, L. G. (1982), *Middle Atmosphere Program Handbook Vol. 4*, edited by C. F. Sechrist, Jr., SCOSTEP Secretariat, Dep. Elec.and Computer Eng., Univ. IL, Urbana-Champaign

Björn, L. G. (1984), *Adv. Space Res.*, 4, 145.
Björn, L. G., et al. (1985), *J. Geophys Res.*, 90, 7985.
Kopp, E., et al. (1985a) *ESA-SP-229*, 117.
Kopp E., et al. (1985b), *ESA-SP-229*, 125.
Olivero, J. J., and G. E. Thomas (1986), *J. Atmos. Sci.*, *43*, 1263.
Philbrick, C. R., et al. (1984) *Adv. Space Res.*, *4*, 153.
Thomas, G. E., and C. P. McKay (1985), *Planet. Space Sci.*, *33*, 1209.

SUPER CAMP establishes a project which should combine efforts of scientists in the USA, Canada, Europe, and the USSR to conduct coordinated measurements from different places around the geographic pole in summer 1989.

WHAT DO WE KNOW ABOUT CAMP?

Observation	NLC observation on ground
	NLC observation from airplanes
	UV scatter experiments
	    SME satellite
	    Sounding rockets
	Charge detection on NLC particles

Dynamics	Extreme low temperatures High mesopause Small turbulent layers Layers of supersaturated water vapor Westward winds at NLC altitudes

Composition	High mass water cluster ions
	Signature of turbulence
	    Atomic oxygen
	    Nitric oxide
	    Electron density
	Anomalous densities of minor constituents
	    Low atomic oxygen
	    Low nitric oxide
	    High water vapor
	    High odd hydrogen
	Reduced vertical mixing

Aerosol	Loss of electrons and positive ions Maximum size of PMC particles: Diameter of 0.14 microns The frequency of PMC occurrence in July Increases with latitude from 25-40% at 65-70°N to 50-70% at 75-80°N
Electrodynamics	Positive charge at NLC height Negatively charged particles above NLC Possible vertical E fields

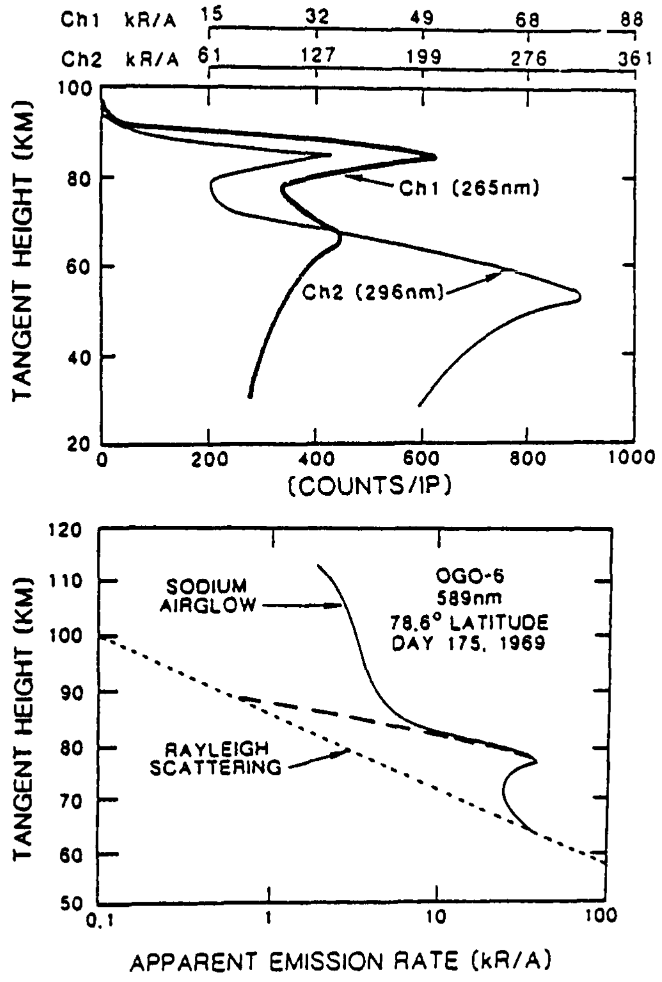

Figure 1. Limb profiles of PMC taken by the SME uv spectrometer (upper panel) and the OGO-6 visible light photometer (lower panel). The lower portions of both data sets are due to scattering from air molecules. The lower peaks in the uv data are due to O_3 absorption.

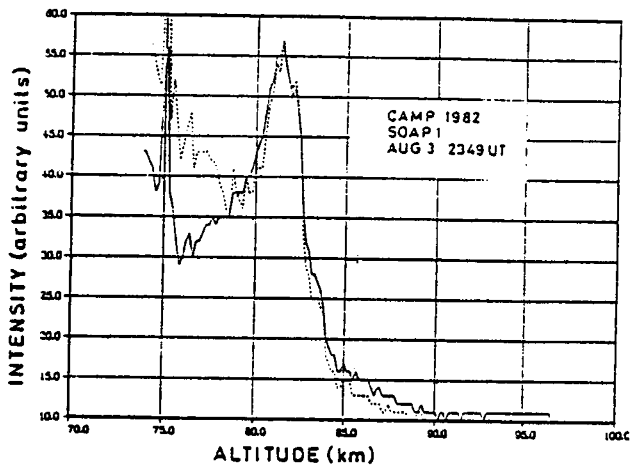

Figure 2. The intensity of visible radiation detected by a side-looking photometer on the SOAP-1 rocket payload in CAMP.

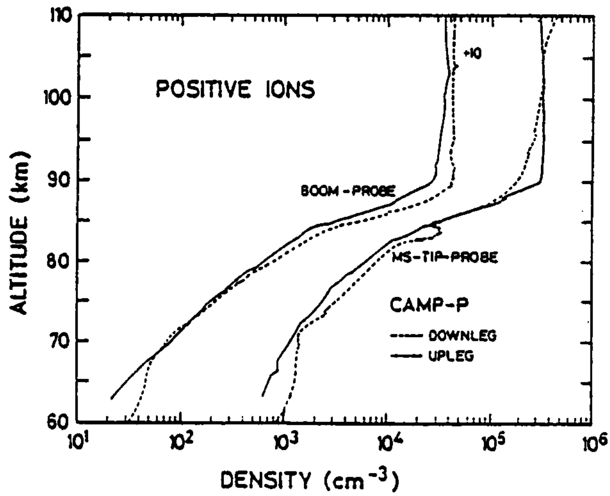

Figure 3. Positive charge density profiles measured on CAMP-P payload. The distinct layer on rocket descent at 83 km altitude is attributed to charged particles at the NLC height.

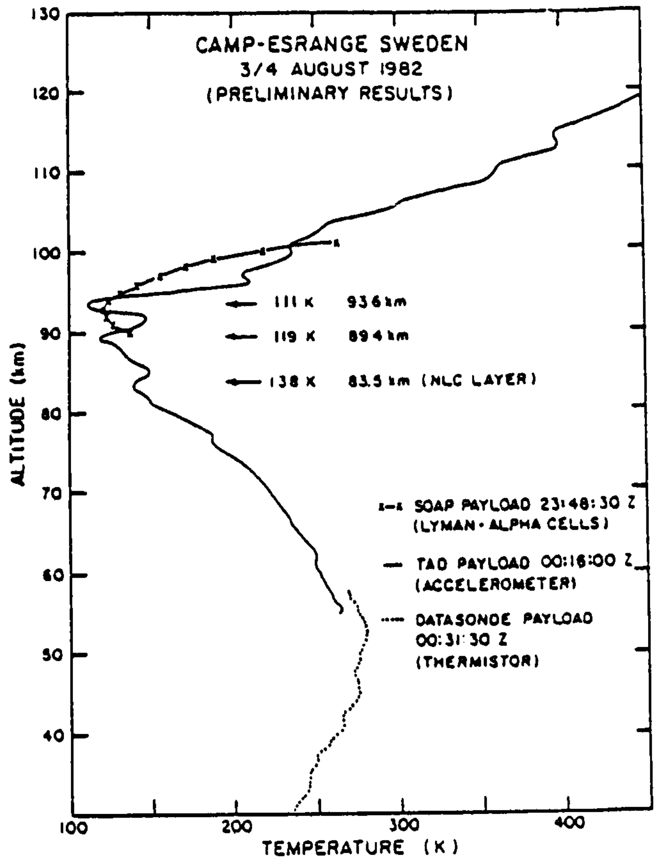

Figure 4. Comparison of three temperature profiles obtained during CAMP.

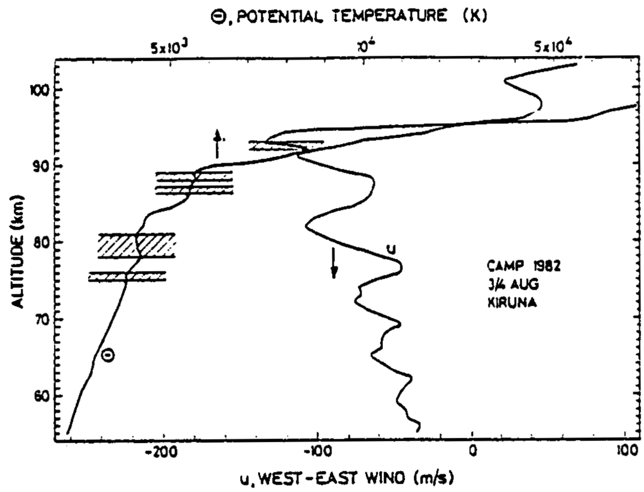

Figure 5. Profiles of the potential temperature and zonal wind velocity obtained from the active falling sphere experiment in CAMP. Five regions with negative potential temperature gradients indicate the presence of turbulence.

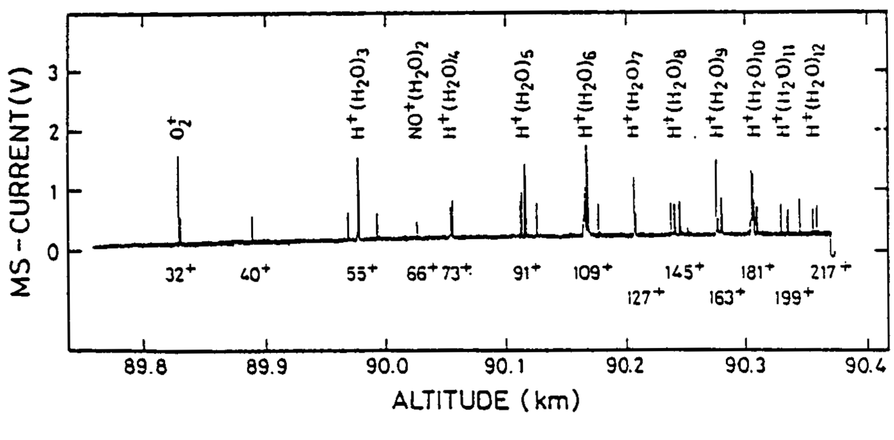

Figure 6. Positive ion spectrum at 90 km altitude on ascent of rocket flight S26/1 on July 30, 1978 above Kiruna.

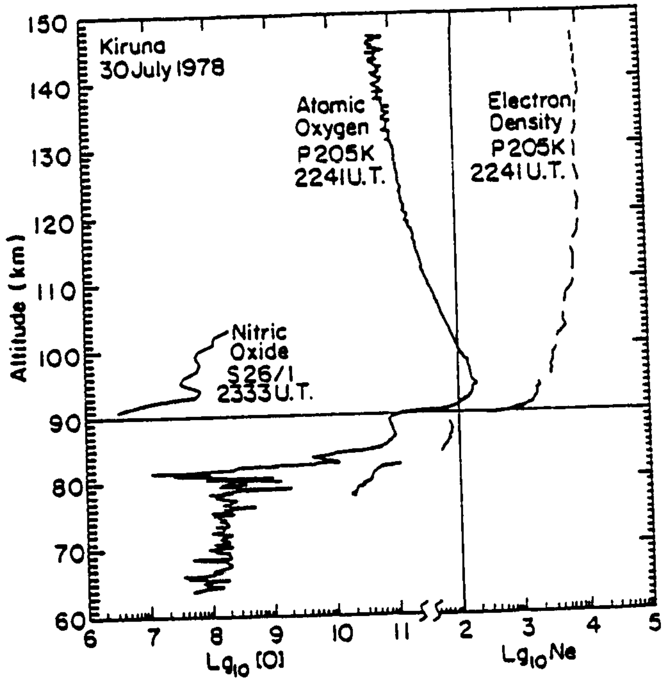

Figure 7. Measured density profile of atomic oxygen and inferred density profile of nitric oxide. To the right in the graph is plotted the unnormalized electron density. The structures at the altitudes 82, 84 and 88 km are most likely signatures of thin turbulent layers

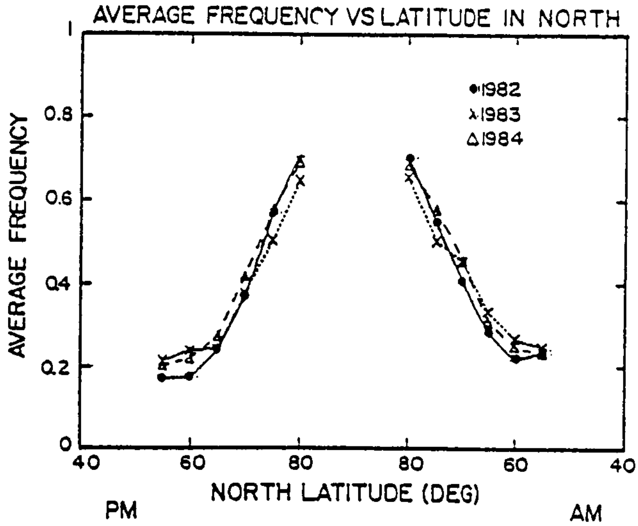

Figure 8. Average occurrence frequency of PMC determined by the SME uv spectrometer for three northern summer seasons. The data have been merged in the interval, 44 days before solstice to 60 days after solstice.

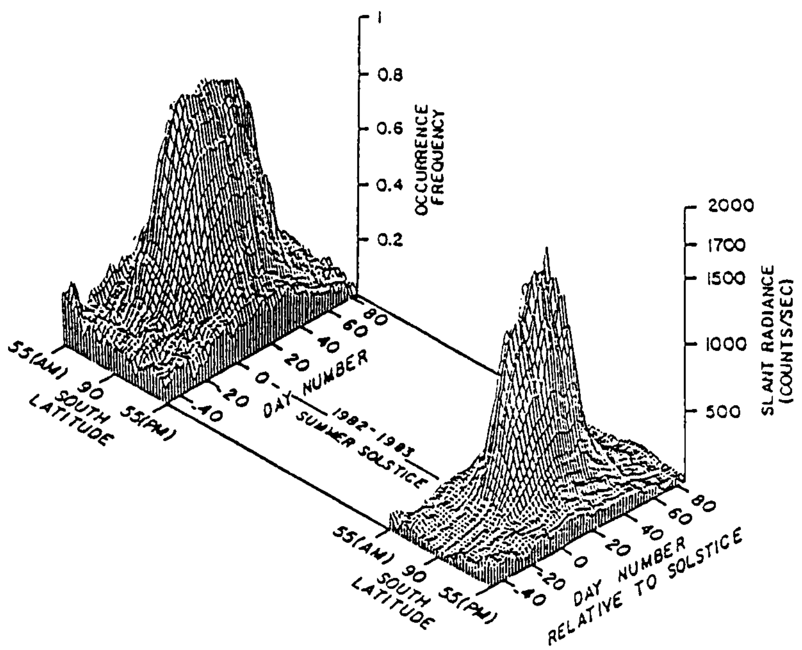

Figure 9. Three-dimensional plots of PMC occurrence frequency and average radiance for 1981/83 southern summer season.

WHY SUPER CAMP?

- To investigate the origin, life time, history and composition of polar mesospheric clouds (PMC) and noctilucent clouds (NLC)

- To discover if the mesopause is located above 90 km and if its temperature is below 120°K over the polar cap

- To find out if polar PMC and NLC are generators of electric fields

- To investigate if the polar mesosphere acts as a cold trap for water vapor in the middle atmosphere in summer

- To know the extreme values of aeronomic parameters such as temperature, vertical wind velocity, densities of O, NO, water vapor and odd hydrogen

- To know if polar mesospheric clouds are noctilucent clouds

PROJECT OBJECTIVES

SUPER CAMP is focussed on a study of the middle atmosphere above the northern polar region from 50° to 80° during summer

- Study of wave dissipation and the effect on temperature and minor constituents at different latitudes

- Measurement of water vapor, odd hydrogen, odd oxygen and temperature

- Measurement of electric fields, charge distribution and conductivity in polar mesospheric and noctilucent clouds

- Measurement of relevant aeronomical data of the polar cap region

- Intercomparison of established and new techniques in remote sensing and rocket measurements

- Measurement of PMC particles

OVERALL CONCEPT

- Sounding rocket measurements from 2 - 3 stations at different latitudes and longitudes with 2 -3 salvos each

- Continuous ground-based measurements over two summer months from selected places around the North Pole

- Remote sensing experiments on airplanes with crossings at "selected" longitude or latitude

- High latitude satellite measurements

OBSERVATION PERIOD

Ground stations:	June 15 to August 31
Airplanes:	July 10 to August 15
Rockets:	July 10 to August 15
Satellites:	June 1 to August 31

ROCKET RANGES

Thule AFB	76.6°N
Ship (USSR)	70-80°N
Andenes	79.2°N
Kiruna	67.5°N

WHY ROCKET MEASUREMENTS AT HIGH LATITUDES?

- To study the region of origin of noctilucent clouds and polar mesospheric ice particles
- To study mesospheric transport, the formation of water ice and its effects on plasma and the distribution of minor species at high latitudes
- To fill the gap of missing data for the modeling of the summer middle atmosphere
- To obtain high resolution density profiles of important minor species as NO, O, H_2O, odd–H and CO in the polar summer middle atmosphere
- To have at least a 60% probability for the presence of mesospheric ice clouds
- To discover if polar mesospheric clouds are noctilucent clouds

ROCKET EXPERIMENTS

Field	Experiments
Dynamics	Falling spheres, pitot tube, pressure gauge, Lyman-alpha occultation, chaff release, ion- and electron-probe, plasma drift experiment
Composition	Mass spectrometer, IR spectrometer, UV spectrometer, resonance fluorescence
Aerosol physics	UV-scatter experiments (layer, particle size)
Nucleation	Gerdien probes
PMC/NLC	dc ion probes, ion mass spectrometer, E-field experiment
Electrodynamics	Charged particle probes, electron-energy spectrum experiment, E-field experiments, Gerdien condenser X-ray detector

ROCKET PAYLOADS

Experiments	PMC-Range (Thule) 77°	NLC-Range (Scandinavian) 68-69°	Payload Code
Medium Size Payloads:			
Optical payloads	1	-	CAMP-XB
Mass spectrometer, electrons, Lyman-alpha, ionization	2	3-4	CAMP-XC
IR payloads	1	2	CAMP-XD
Electrodynamcis, Gerdien probes, PMC finder	6	-	CAMP-XF
Cryosampler, Minor Species	-	2	CAMP-XG
Small Size Payloads:			
Density, U, V, 80-100 km	-	15	CAMP-XX
Chaff clouds, U, V, W	8	10	CAMP-XY
Density, temperature, turbulence	10	8	CAMP-XZ

Rocket payloads in Thule: CAMP-T.
Rocket payloads in Andenes: CAMP-A.
Rocket payloads in Kiruna: CAMP-K.

THULE AFB - GREENLAND

P/L CODE	MOTOR	NUMBER	P/SCIENTIST	AGENCY
CAMP-TB	Taurus-Orion	1	W. Sharp	NASA
CAMP-TC	Taurus-Orion	2	S. Bowhill	NASA
CAMP-TD	Nike-Orion	1	J. Ulwick	US-AF
CAMP-TE	Orion	4	L. Hale	NASA
CAMP-TE	Nike-Orion	2	L. Hale	NASA
CAMP-TF	Nike-Orion	2	R. Goldberg	NASA
CAMP-TY	Loki-Dart	8	H. U. Widdel	NASA/DFVLR
CAMP-TZ	Super-Loki	10	F. Schmidlin	NASA

ANDENES - NORWAY

P/L CODE	MOTOR	NUMBER	P/SCIENTIST	AGENCY
CAMP-AC	Nike-Orion	2	D. Krankowsky	DFVLR
CAMP-AX	Viper	15	U. vonZahn	DFVLR
CAMP-AY	Loki-Dart	10	H.U. Widdel	DFVLR
CAMP-AZ	Super-Arcas	8	F. J. Lübken	DFVLR/NTNR

KIRUNA - SWEDEN

P/L CODE	MOTOR	NUMBER	P/SCIENTIST	AGENCY
CAMP-KC	Nike-Orion	2	F. Arnold	DFVLR
CAMP-KD	Skylark 6	2	K. Grossmann	DFVLR
CAMP-KG	Orion	2	P. Fabian	DFVLR

PROPOSED GROUND STATIONS

LOCATION	LAT/LONG	EXPERIMENTS	ZONE
Alert	82.3/298.0	Airport	PMC
Nord	81.3/342.7	Airport	PMC
Heiss Island	80.6/ 58.1	MWR	PMC
Spitzbergen	78.1/ 15.4	Lidar, PRE	PMC
Thule	76.6/342.7	Airport	PMC
Resolute Bay	74.7/265.1		PMC
Pt. Barrow	71.2/204.5		PMC
Cape Parry	70.2/235.1		PMC
Ramfjord	69.4/ 19.0	PRE/ISR	NLC
Skibotn	69.3/ 20.2	Lidar	NLC
Andenes	69.3/ 16.0	MST, Lidar, OH-T	NLC
Kiruna	67.8/ 20.5	ISR, Airport	NLC
Söndreström	67.0/309.6	ISR	NLC
College	64.5/211	MST	NLC
Poker Flat	64.5/212		NLC
Aberdeen	56.0/356.8	MWR	NLC
Kühlungsborn	54 / 12.7	MWR	NLC
Sheffield	53.2/358.7	MWR	NLC
Lindau	52.0/ 12.1	MST	NLC
Saskatoon	52 /253.4	PRE	NLC
Collm	51.2/ 13.0	PRE	NLC

MWR:	Meteor-wind radar
PRE:	Partial reflection
ISR:	Incoherent scatter
MST:	Mesospheric-stratospheric-tropospheric radar
PMC:	Station at polar mesospheric cloud latitude
NLC:	Station at noctilucent cloud latitude

REMOTE SENSING EXPERIMENTS

Field	Experiment	Parameter
Dynamics	MST Radar	$U,V,W,\lambda_x,\lambda_z$, turbulence
	ISR	N_E, T W
	MWR	U,V
	PRE	U,V,N_E
	Lidar	T,λ_z,p
	OI-, OH-interferometer	λ_x,U,V
	NLC observation	U,V,λ_x
Composition	Microwave Experiment	H_2O,O_3,CO
	Lidar	NA,CA,CA^+
	SME satellite	O_3,NO
	Eureca platform	O_3
	UARS satellite	O_3, H_2O
Aerosol Physics	SME satellite	PMC-,NLC-particle size
	NLC pictures	NLC displays
	Lidar	particle detection

U,V,W : Three velocity vectors
λ_x,λ_z : Horizontal and vertical wavelength
N_E : Electron density
T : Atmospheric temperature
p : Atmospheric density

COMMITMENTS FOR ROCKET EXPERIMENTS

USA/CANADA

J. Barcus	University of Denver	CAMP-TE
S. Bowhill	University Lowell/Illinois	CAMP-TC
R. A. Goldberg	NASA/GSFC	CAMP-TE/TF
L. Hale	Penn State University	CAMP-TE
F. Herrero	NASA/GSFC	CAMP-TE
E. J. Llewellyn	Univ. of Saskatchewan	CAMP-TD
J. Mitchell	Penn State University	CAMP-TE
R. Pfaff	NASA/GSFC	CAMP-TF
F. Schmidlin	NASA/GSFC-WFF	CAMP-TZ
E. Sittler	NASA/GSFC	CAMP-TF
J. Ulwick	Utah State University	CAMP-TD

EUROPE

F. Arnold	MPI-Heidelberg	CAMP-KC
P. Fabian	MPI-Lindau	CAMP-KG
K. Grossmann	University of Wuppertal	CAMP-KD

D. Krankowsky	MPI-Heidelberg	CAMP-AC
E. Kopp	University of Bern	CAMP-TC
F. Lübken	University of Bonn	CAMP-AZ
D. Offermann	University of Wuppertal	CAMP-KD
D. Rees	University College London	CAMP-TF
E. V. Thrane	NTNR Kjeller	CAMP-AC/AZ
H. U. Widdel	MPI-Lindau	CAMP-TY/AY
G. Witt	University of Stockholm	CAMP-TF/SLIPS

PRESENT UNCERTAINTIES

- Permission to use Thule base for rocket launches from the Danish Government
- CEDAR participation
- Availability of MST radar at Thule AFB
- Research airplane for microwave and NA-lidar measurements (Kiruna to Spitzbergen and Söndreström to Thule)
- Contribution of USSR rocket and ground-based measurements
- Operation of SME UVS experiment

SCIENTISTS WHO EXPRESSED THEIR INTEREST TO PARTICIPATE IN THE PROJECT SUPER CAMP

1. EXPERIMENTS

1.1 Ground-Based

B. Balsley, USA	MST
M. L. Chanin, France	Lidar, NLC, T
M. Gadsden, UK	MWR, V, U
D. Gavine, UK	NLC-Pictures
B. Hultqvist, Sweden	EISCAT, ISR, T, Winds
S. Kato, Japan	MWR, MU radar
E. S. Kazimirovsky, USSR	A1, LF measurements
J. Lastovicka, CSSR	Absorption in D region
E. J. Llewellyn, Canada	Ozone
A. Manson, Canada	Winds, OH-interferometer
J. de la Noë, France	Ozone
R. Hillka, SF	Riometers
J. Röttger, FRG/Sweden	EISCAT, ISR, Winds, T, N_E
K. Schlegel, FRG/Sweden	EISCAT, ISR, Winds, T, N_E
R. Schminder, GDR	Tidal winds, Mean winds
M. J. Taylor, UK	OH, OI-structure, NLC-imaging
B. J. Watkins, USA	MST, Söndreström
N. Wilhelm, Sweden	NLC-pictures
U. von Zahn, FRG	Lidar, T, Density
C. S. Gardner, USA	Lidar, NA, Tides
C. R. Philbrick, USA	Lidar
P. Stanuning, DK	Riometers

O. Lado-Bordowsky, France	Interferometer

1.2 Airplane

G. K. Hartmann, FRG	Ozone, Water vapor
K. Künzi, CH	Ozone, Water vapor

1.3 Balloons

J. G. Anderson, USA	Lidar, Minor species
J. R. Barcus, USA	E-fields
R. H. Holzworth, USA	E-fields
I. Iverson, DK	E-fields

1.4 Rockets

F. Arnold, FRG	Ion mass spectrometer
J. Barcus, USA	X-ray
S. Bowhill, USA	N_E, Lyman-alpha, E-field, Turbulence
H. Duscha, FRG	Cryosampler
P. Fabian, FRG	Cryosampler
R. A. Goldberg, USA	E-field, Energetic particles
K. U. Grossmann, FRG	IR Spectrometer, Minor species
L. Hale, USA	E-field (ac/dc), Mobility, Probes
F. Herrero, USA	Wind, Temperature
E. Kopp, CH	Ion mass spectrometer, Probe
D. Krankowsky, FRG	Neutral/ion mass spectrometer
F. J. Lubken, FRG	Probes, Turbulence
J. D. Mitchell, USA	Conductivity, Mobility
E. J. Llewellyn, Canada	Ozone
D. Offermann, FRG	IR spectrometer, Minor species
R. Pfaff, USA	E-field
D. Rees, UK	PMC-Particle size, Concentration
F. Schmidlin, USA	Density, Temperature
W. E. Sharp, USA	O, OH, H, Ozone, NO
E. Sittler, USA	Electron energy
G. I. Tulinov, USSR	Neutral/ion composition, T, Winds
E. V. Thrane, Norway	N_E, Turbulence
H. U. Widdel, FRG	Chaff, Winds, Windcorner
G. Witt, Sweden	Particles and layer of PMC/NLC
U. vonZahn, FRG	U, V, Winds, Density

1.5 Satellites

F. Taylor, UK	Eureca, Water vapor, Aerosol
G. E. Thomas, USA	SME, PMC, UV scatter

2. MODELS

K. S. W. Champion, USA	Dynamics
D. K. Chakrabarty, India	Composition
A. Ebel, FRG	Models
D. C. Fritts, USA	Dynamics, Temperature
M. Gadsden, UK	NLC formation
M. A. Geller, USA	Dynamic modeling

J. C. Gerard, B	1-D, 2-D models
R. Hilkka, SF	D-region models
E. S. Kazimirovsky, USSR	Dynamics
M. Memmersheimer, FRG	2-D models
R. G. Roble, USA	Models
S. Solomon, USA	2-D models
G. E. Thomas, USA	PMC model
A. M. Zadorozhny, USSR	Ion model

3. ADMINISTRATORS, JOURNALISTS

L. Björn, Sweden	SSC
K. Lundahl, Sweden	SSC
W. Schröder, FRG	Scientific Press

APPENDIX 9

PROPOSAL FOR NEW PROGRAM

MAS -- MIDDLE ATMOSPHERE STUDY

S. A. Bowhill, Chairman, MAPSC

During the period of MAP and MAC, the scientific activities involving international cooperation in the middle atmosphere have expanded considerably. The following is a partial list of the activities that have taken place under MAP:

Definition of scientific problems in the middle atmosphere;
Planning and execution of intensive observation campaigns;
Development of new observing techniques;
Establishment of networks of observing stations;
Commencement of long-term observing programs;
Initiation of a regular series of workshops on subjects of continued technical and scientific concern;
Setting up of a publication program;
Development of mechanisms for data interchange, cataloging and archiving.

Some of these activities must certainly continue to have the international coordination that SCOSTEP can provide. The new program STEP will afford a suitable framework, but it does not begin until one year after MAC ends on December 31, 1988.

The MAPSC therefore

> RECOMMENDS that the program MAS (Middle Atmosphere Study) be authorized by SCOSTEP for the period January 1, 1989 through December 31, 1989, for the purposes of:
> (a) Continuing the ongoing MAP programs of critical importance through to the beginning of STEP; and
> (b) Allowing the MAPSC to identify those parts of MAP that involve long-term efforts and should be recommended to the STEP Steering Committee for incorporation in that program.

APPENDIX 10

REPORT ON MASH WORKSHOP, ADELAIDE, 18-19 MAY 1987

A. O'Neill

The first Workshop on the Middle Atmosphere of the Southern Hemisphere (MASH) was held at the University of Adelaide on 18 and 19 May 1987. It preceded and complemented a Workshop on Gravity Waves and Turbulence in the Middle Atmosphere (GRATMAP). Twenty-seven papers were presented, six of which were invited. Topics covered were:

1. Intercomparison of observations
2. Climatology
3. Waves
4. Modeling
5. Transport, chemistry and ozone hole.

1. In recent years, satellite measurements have greatly alleviated the shortage of data for the Southern Hemisphere, but the reliability of analyses made from such data is still in question because there are large areas where there are no radiosonde measurements of the troposphere. A paper (Grose and O'Neill) summarizing findings of a workshop on the intercomparison of data from different sources (held in Williamsburg, April 1986; full report in preparation) showed that there are often large quantitative differences between dynamical quantities derived from different analyses. This finding limits the type of diagnostic study that can be undertaken at present.

2. Studies of the climatology of the middle atmosphere of the Southern Hemisphere, based on data from satellites, lidars, radars, radiosondes and rockets, were presented. Knowledge of the large-scale circulation of the region falls far short of that for the Northern Hemisphere. There were two papers (Newman et al., and Phillpot) on the spring reversal of the circulation in the Southern Hemisphere. The dynamics of the phenomenon might have a bearing on the formation of the "ozone hole" over Antarctica.

3. A new analysis of large-scale waves in the Southern Hemisphere was described (Hirota and Hirooka). Higher mode Rossby waves and medium-scale traveling waves were identified in the middle atmosphere.

4. Most of the studies that have been conducted so far with three-dimensional models have concentrated on the Northern Hemisphere, a fact reflected by the absence of contributed papers on 3-D modeling to this session of the Workshop.

5. A summary of satellite and ground-based measurements of ozone in the Southern Hemisphere (Schoeberl and Newman) was the focus for a lively session on the question of the Antarctic "ozone hole". Contributed papers dealt with transport of ozone and measurements of aerosols.

The Workshop highlighted some of the inadequacies in our present understanding of the middle atmosphere of the Southern Hemisphere. Three broad areas (among many) requiring much more work are 3-D modeling; connections between the troposphere and middle atmosphere; and interhemispheric coupling.

Papers presented at the MASH (and GRATMAP) Workshops will be published in a special issue of Pure and Applied Geophysics.

APPENDIX 11

CZECHOSLOVAK ACTIVITY IN MAC (APRIL 1986-APRIL 1987)

J. Lastovicka

The Czechoslovak national MAC program consists of six scientific subprograms.

1. Disturbances of the Atmosphere at Heights of 120 to 40 km by Penetration of Meteoroids of Metre and Decimetre Dimensions" - Dr. Ceplecha, Astronomical Institute, Czechoslovak Academy of Science, Ondrejov.

Systematic photographic observations of fireballs were performed at 18 stations in Czechoslovakia, 22 stations in the FRG, fourf stations in the GDR and seven stations in The Netherlands, yielding multistation records of 47 fireballs during this period. Results on the most significant five fireballs have already been published in the SEAN Bulletin. Detailed velocity data on the fireball of August 3, 1984, were used for the determination of the ratio of air densities at different height intervals in a total range of 80 to 19 km assuming a smooth height change of the ablation coefficient.

2. "Meteor Radar Observations" - Dr.Simek, Astronomical Institute, Czechoslovak Academy of Science, Ondrejov.

Long-period radar observations (since 1958) of Perseid meteor shower in Canada and Czechoslovakia were evaluated from the point of view of development of activity of this shower (Simek, McIntosh, 1986, Bull. Astr. Inst. Czech. *BAC-37*, 146; Simek, 1987, *BAC- 38*, 1). The activity of the Giacobini shower was studied by Simek (1986, *BAC-37*, 246). A synthesis of the Quadrantide 1968 shower activity observations at five observatories on three continents was made by Simek (1986, BAC-37, 297).

These two subprograms belong to GLOBMET.

3. "Winter Anomaly" - Dr. Lastovicka, Geophysical Institute, Czechoslovak Academy of Science, Prague.

The ionospheric radio-wave absorption in Central Europe was relatively high in the first half of the winter 1986/87 in accordance with "supernormal" stratospheric conditions. As stratwarm processes progressed in the second half of the winter, the absorption became evidently depressed and reached a broad minimum in late February -- very early March 1987, which was attributed to the stratwarm-associated reversal of the lower thermospheric zonal wind (~ 95 km).

4. "Aeronomic Studies with the use of Ground-Based Measurements of Radio-Wave Propagation" - Dr. Boska, Geophysical Institute, Czechoslovak Academy of Science, Prague.

The empirical relation between the A3 absorption and f_0F2 was used for estimating the NO concentration by an improved method. The resulted concentration of NO is 7×10^{13} m^{-3} in 88-90 km, which is a reasonable value in comparison with the results of other authors.

5. "The Interplanetary Magnetic Field Effects in the Ionosphere and Atmosphere" - Dr. Lastovicka, Geophysical Institute, Czechoslovak Academy of Science, Prague.

The IMF sector structure effects in the height of constant pressure levels, temperature, wind speed and direction above Berlin between 1000 - 10 hPa displayed the only persistent and statistically significant effect (even if rather weak) in the troposphere at 500 hPa. The effect of the

IMF sector structure in total ozone in midlatitude Europe was found to exist for proton sector boundaries, while it was insignificant and negligible for common sector boundaries. The study of the IMF sector structure effect in ozone in the upper stratosphere is under way.

6. "The Dynamics of Penetration of Convective Clouds into the Stratosphere" - Dr. Podhorsky, Slovak Hydrometeorological Institute, Bratislava.

The algorithm of the dynamic recognition of development of convective cloudiness was established with a particular emphasis on the penetration of cumulonimbus clouds into the stratosphere. Another computer code was developed on the basis of cluster analysis for computing advective-convective tendencies. Case studies for 18 and 19 August 1986 were made. The top boundaries of supercells and cumulonimbus clouds reached 13-14 km on these days.

INTERNATIONAL SYMPOSIUM "SOLAR ACTIVITY FORCING OF THE MIDDLE ATMOSPHERE"

The symposium is organized by the IAGA Working Group "External Forcing of the Middle Atmosphere" (co-chairmen J. Lastovicka and R. F. Donnelly) will be held in the Castle of Liblice (about 30 km north of Prague, Czechoslovakia) on 4-8 April 1989. Topics: Solar activity (ultraviolet, X-ray and solar constant variations; solar wind, high energy particles, interplanetary magnetic field and geomagnetic activity) influences on the stratosphere, mesosphere, lower thermosphere and lower ionosphere.

Language: English. Expected costs: $180-190 US ($120-130 for accompanying persons), includes registration fee, full board and accommodation for 5 days at the Castle, social program, conference materials and transportation Prague-Liblice and back.

For more information on the symposium, contact Dr. J. Lastovicka, Geophysical Institute, Bocni II, 141 31 Praha 4, Czechoslovakia.

APPENDIX 12

MAP ACTIVITIES IN FINLAND IN 1986-1987

1. Ionospheric Absorption Measurements

The Finnish riometer network includes nine stations, from south to north, Nurmijärvi, Jyväskylä Oulu, Rovaniemi, Sodankylä, Ivalo, Kilpisjärvi, Kevo and Hornsund. The stations are located between L values 3.3 and 13. Operating frequencies are 27.6 MHz and 30 MHz. In addition, the frequencies 40 and 51.4 MHz are used at the Sodankylä station. All the data are collected and scaled in Sodankylä. Monthly bulletins are published and they include the following information: absorption values at the first minute of each hour, maximum absorption during each hour and monthly histograms of mean hourly and daily absorption values.

Starting September 1987 the Sodankylä Observatory will operate an east-west riometer network including five stations from Iceland to Sweden: Vidsel, Abisko, Ramfjord, Andoya and Siglufjördur. The riometers operate at the frequency of 30 MHz.

2. Ozone Measurements

Measurements of the total ozone content have been made in Sodankylä starting spring 1987.

3. Theoretical Modeling of the Ionosphere

Theoretical modeling of the D region has been made especially taking into account different ionization processes and the ion chemistry.

4. Special experiments have been performed concerning the lower ionosphere using the EISCAT incoherent-scatter radar.

APPENDIX 13

MIDDLE ATMOSPHERE RESEARCH IN THE GERMAN DEMOCRATIC REPUBLIC 1985-1987

The observational basis of middle atmosphere research in the GDR consists mainly of continuous monitoring of the midlatitude lower ionosphere by means of ground-based radio techniques, i.e.

- Low and medium frequency radio-wave absorption, measured at Kühlungsborn (54°N, 12°E),
- Indirect phase-height measurements of the D region over Kühlungsborn,
- Partial-reflection sounding of the D region at Juliusruh (55°N, 13°E),
- Regular ionograms taken at Juliusruh,
- Meteor radar winds measured at Kühlungsborn,
- Low-frequency ionospheric drift measurements (D1 method) at Collm (51°N, 13°E).

Several of these observations commenced several years ago so that long data series are available. Most of the data are published regularly in monthly data bulletins. These observations were included in the synoptic studies of ionosphere morphology during the MAP/WINE campaign in winter 1983-84, as presented at the IAGA Scientific Assembly in Prague, 1985.

Major methodical improvements of the observational techniques have been achieved. By comparison with rocket data of D region electron densities, the basic assumptions in the interpretation of ground-based radio phase-height measurements have been corroborated. Use of the FM-CW radar principle with partial reflection sounding made the determination of electron density profiles between 70 and 90 km possible even under conditions of high radio interference level in central Europe. At the Collm Observatory a new technique has been developed which measures absolute reflection heights simultaneously with the ionospheric drift, so that vertical wind profiles in dependence on time can be determined.

Aeronomic results obtained from these observations pertain to different fields of middle atmosphere physics, in particular, to the phenomena and mechanisms of meteorological control of lower ionosphere properties and processes, and their application in using data of lower ionosphere monitoring as a sensor of neutral atmosphere parameters and dynamics. For example, midlatitude indirect phase-height measurements over 19 years showed a clear solar-cycle dependence, consistent with rocket data which show a temperature variation by about 6 K between solar minimum and maximum at heights above 55 km. When the solar-cycle variation was removed from the phase-height data by means of a regression analysis, a significant residual variation with a 20-year quasi-cycle was detected, which may be interpreted as a nonsolar climatic variation of middle atmosphere temperatures.

Further, new results were obtained on the effects of high-energy electron precipitation from the magnetosphere into the lower ionosphere at middle and high latitudes, particularly during the post-geomagnetic storm phase. In particular, evidence was found for increased particle precipitation during periods with negative values of the vertical component of the interplanetary magnetic field, B_Z, in the solar-magnetospheric coordinate system. Daily and seasonal variations of the Earth's magnetic dipole axis can explain corresponding variations of particle precipitation being controlled by the sector structure of the interplanetary magnetic field.

Atmospheric cooling rates of the 15 mm CO_2 band in the height range 30 to 110 km have been calculated on the basis of highly resolved transmittances (line-by-line), taking into account non-LTE conditions.

Using mass spectrometer data of molecular and water cluster ions, an estimate of the mixing ratio of neutral water vapor near the mesopause was derived with the aid of a simplified ion chemistry scheme. It turns out that a steep decrease of water vapor with height has to be assumed in order to understand the observed sharp transition from water-cluster to molecular-ion dominated height regions.

References

v. Cossart, G., K. Sprenger, and S. V. Pakhomov, Indirect phase height measurements of the lower ionosphere compared with rocket measurements of D region electron density, *J. Atmos. Terr. Phys., 48*, 355, 1986.

Kurschner, D., and R. Schminder, High-atmosphere wind profiles for altitudes between 90 and 110 km obtained from D1 LF measurements over central Europe in 1983/84, *J. Atmos. Terr. Phys., 48*, 447, 1986.

Taubenheim, J, and G. v. Cossart, The ionospheric D region as a sensor of meteorological parameters of the middle atmosphere, *Beitr. Geophys., Leipzig, 96*, 105, 1987.

v. Cossart, G., and J. Taubenheim, Solar-cycle and long-period variations of mesospheric temperatures, *J. Atmos. Terr. Phys., 49*, 303, 1987.

v. Cossart, G., and J. Taubenheim, Indications of quasi-20-year cycle of middle atmosphere temperatures, *Adv. Space Res., 6*, No. 10, 73, 1986.

Bremer, J., and H. Gernandt, Control of particle precipitation by energy transfer from solar wind, *Mem. Nat. Inst. Polar Res., Spec. Issue, 38,* 138, 1985.

Bremer, J., Control of diurnal and seasonal variation of particle precipitation by regular changes of the interplanetary magnetic field, *J. Atmos. Terr. Phys., 47*, 1123, 1985.

Haus, R., Accurate cooling rates of the 15 µm CO_2 band - comparison with recent parameterizations, *J. Atmos. Terr. Phys., 48*, 559, 1986.

Prasad, B. S. N., and J. Taubenheim, Estimates of mesospheric water vapor based on D region ion composition data, *J. Atmos. Terr. Phys., 49*, 123, 1987.

APPENDIX 14

MAP/MAC ACTIVITIES IN HUNGARY, 1986/87

P. Bencze

Research activity has been carried out according to the program which consists of six topics. In this report only those themes are included in which significant development has been achieved.

1. Changes of Solar and Meteorological Origin in the Mesosphere and Lower Thermosphere

Studying the variations of the level of atmospheric radio noise in the VLF band in the Geodetic and Geophysical Institute, Hungarian Academy of Sciences, Sopron, it has formerly been found that the effect of Forbush decreases grows with diminishing frequency. This effect is due to the decreased ionization in the lower part of the D region where galactic cosmic rays are one of the main sources of ionization; further, the growing amplitude of the effect with decreasing frequency is a consequence of the augmented attenuation of the waves in the Earth-ionosphere waveguide approaching the cutoff frequency of the waveguide. By analyzing the level of atmospheric radio noise in the ELF band it has recently been found that with the decrease of frequency passing the cutoff frequency, the effect of Forbush decreases begins again to decrease.

Similarly in the Geodetic and Geophysical Research Institute the analysis of the ionospheric absorption of LF radio waves has shown that also storm aftereffects can occur in the lower ionosphere associated with high-speed plasma streams in the solar wind, if the solar wind velocity is larger than 600 km^{-1}.

2. Turbulence

The method for the determination of turbulent parameters in the lower thermosphere, based on the parameters of sporadic E layers as well as on models of the ionosphere and the neutral upper atmosphere, has been developed in the Geodetic and Geophysical Research Institute, Hungarian Academy of Sciences, Sopron. In addition to the correction introduced earlier, the computation of both components of the vertical shear of the horizontal wind has been made possible as well as the tracing of the right height variation of the turbulent diffusion coefficient has been achieved by introducing new relations and new measured parameters.

APPENDIX 15

ATTENDEES AT THE 1987 MAPSC MEETING, VANCOUVER, CANADA

Ahluwalia, H. S.
Balsley, B. B.
Bojkov, R. D.
Bowhill, S. A.
Brown, G.
Chen, A. J.
Forbes, J. M.
Gille,J.C.
Goldberg, R.
Gregory, J.
Gretchko, G.
Hirota, I.
Kato, S.
Kopp. E.
Labitzke, K.
Lastovicka, J.
Liu, C. H.
Manson, A.H.
O'Neill, A.
Pommereau, J. P.
Ranta, H.
Roper, R. G.
Simon, P.C.
Taubenheim, J.
Thomas, G. E.
VanZandt, T.E.
Vincent, R. A.
von Zahn, U.

APPENDIX 16

MAP STEERING COMMITTEE MEETING
1830 Tuesday, August 18, 1987
Room 210 Angus, University of British Columbia
Vancouver, Canada

Agenda

1. Opening Remarks, Bowhill
2. Approval of Agenda
3. Minutes of Last Meeting, Toulouse, 1986
4. Standing Committee Reports
   Data Management, Hartmann/Hirota
   Publication, Edwards/Liu
5. MSG Reports
   MSG-5, Ions and Aerosols, Arnold/McCormick
   MSG-8, Atmospheric Chemistry, Witt
   MSG-9, Measurement of Middle Atmosphere Parameters by Long Duration
   Balloon Flights, Blamont
6. Project Reports
   AMA, Hirasawa
   ATMAP, Forbes
   DYNAMICS, Labitzke
   GLOBMET, Roper
   GLOBUS, Pommereau
   GOSSA, McCormick
   GRATMAP, Fritts
   MAC-EPSILON, Thrane
   MAC-SINE, Thrane
   MAE, Goldberg
   MASH, O'Neill
   NIEO, Kato
   OZMAP, Heath
   SSIM, Simon
   SUPER CAMP, Kopp
   WINE, vonZahn
7. Status of New Projects Proposed Last Time
   EMA, Equatorial Middle Atmosphere, Kato
   EMMA, Energy and Momentum in the Middle Atmosphere, Bowhill
   NITROX, Nitric Oxide-Odd Oxide Study, Witt
8. Proposals for New Workshops
   SuperCamp, Boulder, March 1988
   MST Radar, Kyoto, October 1988
9. Regional Consultative Group Report, Chanin
10. Status of Revised MAP Planning Document, Vincent
11. Coordination with STEP, Bowhill
12. Report on MASH/GRATMAP Workshop, O'Neill/Fritts
13. Plans for Final MAP Symposium, 1988, Bowhill/Labitzke
14. Reports from National Representatives
15. Other Business
16. Next Meeting

INTERNATIONAL WORKSHOP ON NOCTILUCENT CLOUDS
Boulder, Colorado
March 16-18, 1988

Abstracts of Invited Papers

Dynamics, Radiation, and Photochemistry in the Mesosphere: Implications for the Formation of Noctilucent Clouds

R. R. Garcia, National Center for Atmospheric Research, Boulder, CO 80307

The nature of noctilucent clouds, which occur at very great heights and high latitudes during the summer season, has remained something of a mystery for over one hundred years. The realization that the summer mesopause is the coldest region of the Earth's atmosphere, together with the possibility that transport by atmospheric motions could maintain a substantial mixing ratio of water vapor against very rapid chemical destruction, has led to the present consensus that noctilucent clouds are formed of water ice. A number of recently developed numerical models have been successful in simulating cloud particle distributions whose characteristics are consistent with satellite radiance observations. However, due to the scarcity of data on temperature, dynamics, and water vapor abundances, these models have had to rely on a number of assumptions about the behavior of these quantities.

In this paper, we attempt to illustrate by means of numerical calculations how various dynamical and photochemical processes interact to produce the unique environment that makes possible the existence of noctilucent clouds. We focus in particular on how radiative heating and thermal relaxation influence the altitude and strength of gravity wave breaking, and on the effects of such wave breaking on the circulation, temperature distribution, and transport of water vapor near the summer mesopause. We also show that, if present understanding of hydrogen chemistry in the mesosphere is even approximately correct, variation in Lyman-alpha radiation should have a significant effect on water vapor abundances near the summer mesopause and, therefore, on the occurrence of noctilucent clouds.

On the Role of Gravity Waves in the Summer Mesosphere

M. McIntyre, University of Cambridge, United Kingdom
(Abstract not available)

Energetics of the Mesopause Region

R. Roble, National Center for Atmospheric Research, Boulder, CO 80307

A self-consistent global average model of the coupled thermosphere, ionosphere and mesosphere is used to examine the structure of these regions for solar minimum and maximum conditions. The model solves for the compositional profiles of O, O_2 and N_2 coupled through major constituent diffusion equations. It also includes as minor species with transport and appropriate photochemistry: $N(^4S)$, NO, H_2, H, H_2, CH_4, CO, CO_2 and in photochemical equilibrium with the above: O_3, $O(^1D)$, $N(^2D)$, NO_2, OH, H_2O_2 and HO_2. The distribution of the passive tracers He and Ar are also calculated. For ions in the E- and F-ionospheric regions we calculate O^+ including diffusion and O_2^+, N_2^+, NO^+ and N^+ in photochemical equilibrium. The model also includes a D-region ion chemistry code that solves for various positive and negative ion species. The model has separate thermodynamic equations for electron, ion and neutral temperatures and appropriate energy exchange processes. The neutral gas receives

energy from solar photoelectron, O_2 absorption in the Schumann-Runge continuum and bands and O_3 absorption in the Hartley and Huggins bands, excess energy from exothermic ion-neutral and neutral-neutral chemical reactions including atomic oxygen recombination, $O(^1D)$ quenching and also from auroral electron precipitation and Joule dissipation. Cooling includes CO_2 - 15 μm, NO - 5.3 μm and O - 63 μm emissions and molecular and eddy thermal conduction.

The calculated globally averaged temperature and compositional structure, using Atmosphere Explorer E solar EUV flux measurements for solar minimum and maximum conditions, are compared with the structure obtained from MSIS-86, above 85 km, and the U. S. Standard Atmosphere below 85 km. Perturbations of the global mean structure by dynamic processes operating in the mesopause region will be discussed.

Airglow and Photochemistry in the Upper Mesosphere

J. Meriwether, University of Michigan, Ann Arbor, MI 48109

In recent years our understanding of the photochemistry of the upper mesosphere, $80<h<100$ km, has undergone a major evolutionary cycle leading to the improved appreciation of the complexities of the chemistry of the hydrogen-oxygen family in the mesosphere. Studies of the OH airglow now show that only one production process, $H + O_3 \Rightarrow OH^* + O_2$, needs to be invoked to explain the vibrational population distributions seen. Compelling and powerful arguments now show that the hydroperoxyl radical, HO_2, plays a negligible role in the photochemistry of this region. In place of the additional hypothesized production for the lower vibrational states of OH*, the new works shows that the higher vibrational states of OH are preferentially quenched by O_2 and N_2. Improved computations of the dipole moment function of OH have resulted in a new set of transition probabilities that agree well with airglow spectra. In similar fashion, our understanding of the photochemistry of the oxygen airglow emissions has evolved. Recent papers on the results of the ETON (Energy Transfer and Oxygen Nightglows) campaigns have demonstrated how necessary and important simultaneous measurements of *in situ* atomic oxygen concentrations are to the proper interpretation of the various oxygen airglow volume emission profiles. There is no longer any doubt that the Barth process is the major production source for the multitudes of metastable energy states in the molecular oxygen potential energy manifold. Energy transfer and quenching reactions within this set of metastable states complicate greatly the interpretation of the existing measurements. Continued progress in the understanding of the oxygen airglows will require substantial laboratory work combined with additional ETON-like rocket campaigns that are designed to observe simultaneously the vertical profiles of atomic oxygen and the molecular oxygen optical emissions.

Ion Chemistry of the Cold Mesopause Region

G. C. Reid, Aeronomy Laboratory, NOAA, 325 Broadway, Boulder,CO 80303

The ion composition of the atmosphere undergoes a very marked transition in the vicinity of the mesopause. At lower altitudes the positive ions are dominated by relatively heavy cluster species formed in the high-pressure regime in which three-body reactions are efficient, while lighter molecular species become dominant at higher altitudes. This transition is even more marked in the high-latitude summer, when the extreme cold favors the growth of large proton hydrates that probably represent the early stages in the formation of ice particles by ion nucleation.

After a brief historical introduction to the measurements of ion composition in the mesosphere, the paper reviews existing knowledge of the sources of ionization, the ion reaction paths, and the kinetics of the reactions in the mesopause region. Model simulations of the steady-state positive-ion composition are used to discuss the dependence of composition on temperature and water-vapor concentration, and the relevance to noctilucent cloud formation. Mass-spectrometer measurements made during NLC conditions are reviewed briefly, and the comparison with model calculations is discussed. Metal ion species and negative ions in the cold mesopause region are touched on superficially.

Electrodynamics of the High Latitude Mesosphere

R. A. Goldberg, Laboratory for Extraterrestrial Physics, NASA/Goddard Space Flight Center, Greenbelt, MD 20771

The discovery of apparent large (V/m) electric fields within the mesosphere suggests that this region is more active electrically than originally suspected. High-latitude observations have been particularly productive in developing new concepts regarding mesospheric electrodynamics. Several high-latitude observations of large mesospheric fields have been made under both quiet and aurorally active conditions, but always below heights where enhanced ionizing radiations could significantly penetrate. Two measurements from Andøya, Norway, have also produced an anticorrelation of horizontal electric field directions with neutral wind velocities, leading to the theoretical description of a newly defined mechanism for V/m electric field generation involving wind-induced separation of charged aerosols. Evidence for mesospheric aerosols and winds exist at all latitudes, but is most evident at high latitudes during the appearance of noctilucent and/or polar mesospheric clouds. New measurements show an influence of such clouds on electric fields mapping downward from the ionosphere, and future projects are planned to continue the study of mesospheric cloud influences on the local electrical environment. Recent results also demonstrate that middle atmospheric electrical parameters can be used to track neutral air turbulence and wave structure at high latitudes, thereby providing a powerful tool for study of mesospheric neutral dynamics and its relationship to the electrodynamics question. This overview concentrates on the various subjects outlined above.

Radar Measurements of the High-Latitude Mesosphere

J. Röttger, EISCAT Scientific Association, P. O. Box 812, S-981 18 Kiruna, Sweden

Several radar methods can suitably be applied to study the structure and dynamics of the mesosphere. These apply to radars operated in the medium-frequency or high-frequency range (MF- or HF-radars) and in the very-high-frequency and ultra-high-frequency range (VHF- and UHF-radars). The MF or HF radars are applied in the particle reflection mode to deduce the electron density with the differential absorption technique or mostly in the spaced antenna mode to study turbulence and to measure wind velocities. In the low VHF band, meteor radars are used to observe winds, and the mesosphere-stratosphere-troposphere MST radars operating in the VHF band are used to study turbulence, waves and winds. In the upper VHF band and in the UHF band radars are applied in the Thomson scatter mode to measure electron density, collision frequency and temperature as well as wind velocities.

The principal scattering mechanisms, namely, partial or Fresnel reflection from electron density gradients, Bragg scatter irregularities and Thomson scatter from thermal electron-density fluctuations will be outlined. The technical layout of the currently used radar systems will be described as well as typical data-acquisition and analysis techniques and the data interpretation will be summarized. Special techniques, such as the spaced antenna techniques to measure winds, momentum flux, gravity wave parameters, and turbulence structures will be depicted. Recently developed techniques, such as the imaging Doppler interferometry, the spatial domain interferometry, and the frequency domain interferometry will be discussed.

Finally, the interrelation of gravity waves and turbulence will be sketched by elucidating the possibility of wave breaking and dissipation. Typical features of the high-latitude mesosphere such as particle precipitation, auroral heating, vertical diffusion processes and effects of the cold arctic mesopause on the formation of radar refractive index structures will be summarized by discussing some recent relevant radar observations. It will be stressed how multifrequency radar studies are expected to shed more light into the understanding of these processes and that the combination of radar observations with rocket, and active and passive optical experiments constitutes a useful contribution.

NLC Observations in the USSR

O. Avaste, Tartu Observatory, USSR

(Abstract not available)

NLC Observations in the UK

M. Gadsden, Physics Department, Aberdeen University, Aberdeen AB9 2UE, Scotland (UK)

This is an account of the current status of noctilucent cloud observations made from ground level in northwest Europe. An ever-increasing team of trained volunteer observers is watching the summer night sky from latitudes between 50°N and 65°N. This team reports to a single coordinator who is charged with collating the reports and preparing and publishing an annual summary. Although the observers do not in general have professional qualifications, the quality of the observational data has been, and remains, high; there are now well over 20 years' consistent data available for synoptic studies. Analyses that are currently in progress include: comparison of meteor train drift data with the night-to-night occurrence of noctilucent clouds; study of the morphology of wave-like patterns seen in noctilucent clouds, including the presence of gravity-wave breaking and of solitary waves; systematic measurement of heights of noctilucent clouds by triangulation (parallactic photography from widely separated sites).

Climatology of Polar Mesospheric Clouds: Part 2

G. E. Thomas, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309
J. J. Olivero, Department of Meteorology, Pennsylvania State University, University Park, PA, 16802

Analysis of data collected by the Ultraviolet Spectrometer Experiment on the Solar Mesosphere Explorer satellite is described. The data are in the form of scattered radiances of polar mesospheric clouds at the atmospheric limb, for summer seasons beginning in December 1981, through to the 1985-1986 southern season. This includes four seasons in the north and five in the south. The radiances are at the two wavelengths of 265 nm and 296 nm, and are taken at a height resolution of 3.5 km.

The earlier analysis of Olivero and Thomas [1985] comprised six seasons, and did not employ a subtraction of the Rayleigh background. In the current study, we report on the entire SME data set, and furthermore have corrected the data for the atmospheric background. The current study has revealed new features of the PMC climatology: (1) northern PMC, at their peak activity, extend farther equatorward than their southern PMC counterparts, (2) northern PMC and noctilucent clouds have different seasonal and latitudinal behavior, (3) PMC have no

significant longitudinal variability over the 67% of the area of the polar cap sampled by SME in the four-year period 1981-1985, (4) there is no effect of the auroral zone in the spatial distribution of PMC occurrence frequency; and (5) comparison of a rocket climatology of mesospheric temperature at Point Barrow, Alaska (71°N), and PMC occurrence frequency show that both reach their extreme at three weeks past summer solstice.

Interpretation of these new aspects will be given.

In Situ Measurements of the Cold Arctic Mesopause

G. Witt, University of Stockholm, Sweden

There is more and more evidence that the middle atmosphere, especially the summertime arctic mesosphere, is the scene of small-scale phenomena which cannot be understood without knowing in detail how local properties such as composition and temperature are distributed. During the past decades a variety of techniques ranging from passive measurements to active sensing by means of on-board light or electron-beam sources have been introduced for obtaining this information in situ. This review deals mainly with methods that are currently in use: charge detectors, mass analyzers, optical and electron beam backscatter probes, especially their reliability and shortcomings. The discussion is extended to desirable development as well as to the strategy of combining individual instruments into well-coordinated rocket probes and campaigns.

Nucleation and Particle Formation in the Upper Atmosphere

R.G. Keesee, Dept. of Chemistry, The Pennsylvania State University, University Park, PA 16802

In the high latitudes of the summer mesopause, temperatures can be sufficiently cold that the region becomes strongly supersaturated in water at ambient vapor concentrations around a part per million by volume. With supersaturation, water vapor can be removed from the vapor phase to form and grow cloud particles. Meteoric dust and ions are suspected to be the dominant sources of nuclei upon which water can collect. The development of ice particles from cores of meteoric dust involves a process known as heterogeneous nucleation. Particle formation promoted by ionic nuclei is called ion-induced nucleation. The formalisms for these two competitive mechanisms will be presented and applied to conditions of the summer polar mesopause. Results suggest that both processes are feasible mechanisms for initiating noctilucent cloud formation. However, because calculated nucleation rates are highly uncertain, the predominance of one or the other nucleation mechanisms for noctilucent cloud formation cannot be unambiguously established.

Overview of NLC Campaigns, Past and Future

E. Kopp, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland

The use of rocket experiments to study the noctilucent cloud (NLC) appearance at the summer high latitude mesopause started in 1963 and 1964 with temperature soundings by Witt (1968) and with optical diagnostics of the scattered light from the cloud particles by Witt (1969).

In the period 1978 to 1986 four coordinated rocket campaigns took place in Kiruna and Poker Flat. The rocket payloads had instruments to measure temperature, horizontal winds, positive and negative ion composition, electron and total ion density, electric fields, conductivity and mobility. Several passive and active optical experiments were used to measure atomic oxygen, the scattered light from NLC-particles and the light of Lyman-alpha and the Schumann-Runge band. The CAMP (1982), the STATE (1983), and the MAED (1986) Campaigns had supporting measurements from ground (EISCAT, MST-radar, optical and meteor wind radar), from airplane (NLC-detection, H_2O microwave experiment), and from satellites SME and Nimbus 7.

At present, two rocket campaigns are planned for summer 1990 in Kiruna and for summer 1992 at Thule. The 1990 campaign will be focussed to study all kinds of small-scale features tin the neighborhood of NLCs with special emphasis on electrodynamical parameters. The 1992 campaign at Thule will be the delayed SuperCAMP project with the objectives to investigate the structure, physics, and chemistry of PMCs.

References:

G. Witt, *Tellus*, *XX*, 98-114, 1968
G. Witt, *Space Res.*, *9*, 157-169, 1969

Abstracts of Contributed Papers

The Study of Mesospheric Ion Chemistry Using Incoherent Scatter Radar

C. Hall and A. Brekke, The Auroral Observatory, Box 953, N-9001 Tromsö, Norway

It is possible to utilize innovative analysis techniques to incoherent scatter spectra from the height regime 75-90 km and so investigate the ion chemistry in this region. We show how it is possible to estimate negative ion concentrations, ion masses and hence cluster ion hydration path, and Schmidt number. We attempt to demonstrate the contribution incoherent scatter radar can make to summer mesopause chemistry research in polar regions, particularly when used in conjunction with independent temperature measurements.

Detection of Heavy Positive Ions at the Summer Arctic Mesopause with the EISCAT UHF Incoherent Scatter Radar

P. N. Collis, EISCAT Scientific Association, Box 812, S-981 28 Kiruna, Sweden
T. Turunen and E. Turunen, Geophysical Observatory, SF-99600 Sodankyla, Finland

Summertime measurements of the incoherent scatter spectrum from mesospheric heights with the EISCAT UHF incoherent scatter radar have revealed an altitudinally confined layer of much narrower spectra than in the surrounding altitudes. These characteristics are interpreted as the effect of very heavy positive ions, with mean masses in the range 300 to 1000 amu. The layer was observed between 86 and 88 km altitude, and the conditions of the experiment were consistent with those under which noctilucent clouds are expected to occur. These deductions from measurements at 933 MHz are discussed in the light of recent summertime observations by the EISCAT VUF radar operating at 224 MHz.

A Microphysical Model for Polar Mesospheric Cloud Ice Particle Formation

E. J. Jensen, and G. E. Thomas, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309
B. A. Toon, NASA Ames Research Center

The aerosol model developed by Brian Toon and Richard Turco has been used to simulate the formation of polar mesospheric clouds (PMC). The cloud particles are assumed to be composed of water-ice crystals, nucleated by either meteoric dust or heavy ions. All

important physical processes, including nucleation, condensation growth, sedimentation, advection, and diffusion, have been included. Using typical values for parameters such as the atmospheric temperature, pressure, and eddy diffusion coefficient, the simulated clouds achieve albedos similar to PMC albedos measured by the Solar Mesosphere Explorer satellite. The minimum time required for visible clouds to form is about 24 hours. Realistic particle size distributions have been calculated indicating maximum particle sizes of about 50 nm.

Additional processes which appear to be important include local perturbations of the atmospheric temperature and wind speed due to internal gravity waves and tides.

The model has also been used to calculate the effect of collection on PMC particles on the electron density near the mesopause. Preliminary results indicate the observed depletions could be due to the presence of PMC.

Saturation of Gravity Waves

J. Weinstock, NOAA/Aeronomy Laboratory, Boulder, CO 80303

A calculation is made of the turbulence field generated by a breaking gravity wave and the saturation of that wave by the turbulence it generates. "Collapse" restricts the turbulence to reside in sharply defined layers. These layers cause a deformation (steepening) of the sinusoidal shape of the wave and produce higher harmonics. Both the width of a layer and the efficiency of saturation(the ratio of saturation amplitude to instability threshold amplitude) vary with wave frequency. An implication of the layered structure for scalar transport is pointed out.

A Global Climatology of Mesospheric Temperatures Based Upon SME Limb Profiles of Ultraviolet Radiances

R. T. Clancy, and D. W. Rusch, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309-0392

Atmospheric temperature profiles over the altitude range 60-90 km have been derived from the SME ultraviolet limb radiance data set for the period 1982-1986. Latitude coverage is ± 50 degrees about the equator with 5 degree latitudinal resolution and 3.5 km altitude resolution. Derivation of atmospheric temperatures from inverted volume scattering profiles follows directly the lidar technique for measurement of atmospheric temperatures. Monthly averaged temperature profiles provide 3-5 K accuracy at 86 km, with better than 2 K accuracy below 76 km.

Comparison of this SME climatology with MAP and CIRA 1972 climatologies of mesospheric temperatures indicates significant differences, especially at equatorial latitudes. SME temperatures include a striking temperature inversion between 70 and 86 km at the equinoxes for equatorial latitudes. This inversion exhibits a high degree of repeatability over the 5-year period of measurement. No obvious longitudinal dependence is apparent. The development of a winter solstice temperature inversion at lower altitudes for midlatitudes is also evident, and is in accord with lidar results reported by Hauchecorne et al. (GRL, 14, 1987) for 45°N latitude. Furthermore, a significant cooling of winter temperatures at 65 km over the 1982-1986 period is also apparent, particularly at southern midlatitudes. At northern latitudes, this result appears consistent with the lidar results of Chanin et al. (JGR, 92, 1987).

Study of Noctilucent Clouds over Germany Since 1885

W. Schröder, Bremen-Roennebeck, Federal Republic of Germany

The study of noctilucent clouds was begun in the summer of 1885 by Otto Jesse in Germany. In later years (1884-1956) in Germany (50-55°N), the reported number rose and fell, partly depending on the attention given to them by observers.

Since the International Geophsyical Year (1957), a regular watch for the noctilucent clouds has been kept at Roennebeck (53°2N) and Northern Germany.

The objectives of this study are: (a) to determine the frequency of occurrence of noctilucent clouds over Germany and Middle Europe; (b) to determine their lifetime and spatial extent; (c) to measure the height, thickness, and vertical wave amplitude; (d) to investigate the effects of auroral particles bombardment on noctilucent clouds; (e) to study the relationship between mesospheric circulation (seasonal transitions) and frequency of occurrence of noctilucent clouds; and (f) to advance a general theory to explain the main features of noctilucent clouds.

REPORT ON INTERNATIONAL WORKSHOP ON NOCTILUCENT CLOUDS
Boulder, Colorado
March 16-18, 1988

G. E. Thomas, G. B. Bjarnasson, E. J. Jensen, D. Siskind, and A. Stern

INTRODUCTION

A joint meeting was held in Boulder, Colorado, between the ICMUA Working Group on Noctilucent Clouds and the SUPER-CAMP rocket campaign group. Sponsored by SCOSTEP and ICMUA, the intent of the meeting was to bring together experimentalists and theorists in planning a coordinated high-latitude rocket campaign in 1990. Interest in the noctilucent cloud phenomenon has been stimulated recently by several developments; (a) satellite measurements have revealed an extensive ice layer covering the entire polar cap region (polar mesospheric clouds, or PMC) [Thomas, 1984], (b) development of new *in situ* techniques for measuring upper mesosphere properties [Kopp et al., 1987], and (c) theoretical breakthroughs [Solomon and Garcia, 1985] in clarifying the importance of waves in establishing the very low temperatures of the cold summertime mesopause (at about 85 km).

The meeting fulfilled its purpose in bringing together a diverse group of about 20 speakers and 45 participants. Thirteen tutorials and six contributed papers covered a wide range of topics, embracing atmospheric dynamics, photochemistry and airglow, ion chemistry, electrodynamics, thermal budget, wave deposition, turbulence, climatology, and microphysics of ice nucleation. In addition, several reviews were given of rocket and ground-based sounding of the properties of the cold high-latitude summertime mesopause (HLSM). Discussion periods were devoted to the outstanding scientific problems and challenges for the future; these will be described in greater detail below. This report describes briefly the content of the invited tutorial papers, followed by a capsule summary of the main discussion topics. A list of participants is also given.

It is planned to publish papers from the Workshop in a special section of the Journal of Geophysical Research. A follow-on Workshop will be held in Tallinen, Estonia, on July 28-31, 1988. It is hoped that the interest generated at this Workshop will stimulate further research in this highly multidisciplinary area. The Workshop particularly highlighted the need for more investigation by rocket-borne experiments of the unique interplay of dynamical and electrodynamic properties.

TUTORIALS

R. Garcia described two-dimensional model calculations of water vapor and temperature at the HLSM. Nominal values of the input parameters yielded marginal conditions for ice stability; he showed that reducing the thermal relaxation rate by a factor of four created more favorable conditions (a lower and colder mesopause). He also predicted that cloud occurrence should be sensitive to solar-cycle variations of solar Lyman-alpha irradiance. R. Roble described a global average model of the coupled thermosphere, ionosphere and mesosphere which includes all heating and cooling rates known to be of importance in the region above 50 km. He showed that perturbations of the global mean state by the dynamic process of wave breaking is essential in explaining observed low polar mesopause temperatures. M. McIntyre discussed the roles of gravity waves in the HLSM. He focused on the phenomenon of wave dissipation and how it causes cooling and acceleration of the zonal winds. He cautioned that the dissipation and resulting eddy diffusion may be extremely sensitive to the wave parameters. J. Meriwether reviewed recent progress in understanding the excitation mechanisms for the OH Meinel and oxygen airglow emissions in the HLSM.

There is now compelling evidence that a single chemical mechanism (H + O_3) is sufficient to explain all the various measurements of OH* including both high and low vibrational states. G. Reid reviewed gas-phase ion chemistry in the HLSM, showing that the scheme of proton hydrates below 90 km and molecular ions above 90 km is correct in broad outline. However, problems for current models are to explain the very sharp cutoff between the two regions; the distribution of proton hydration order with height, and the presence of a narrow region of electron depletion, which may be associated with negative ions, or negatively charged aerosols. R. Goldberg emphasized recent developments in his survey of the electrodynamics of the region, specifically the discovery of large (of order volts/meter) electric fields in the HLSM. He also described a recent theory by Steve Curtis that explains the observations through a wind shear operating on very slightly charged aerosol particles. J. Röttger described how radar (MF, HF, VHF, and UHF) techniques are applied to study a wide range of phenomena at mesopause heights: winds, gravity wave parameters, turbulence, electron density and particle precipitation. O. Avaste reviewed NLC research in the USSR and in particular the results from Soviet orbital stations. He described a long series of visual sightings by Soviet Cosmonauts, and also four-channel radiometric measurements of NLC in the near infrared. A possible new experiment to be flown on a future mission is a CCD imager, equipped with a filter wheel to measure both NLC and relevant airglow emission features. M. Gadsden demonstrated the value of NLC observations made by an amateur network in the UK over the past 20 years. He also described a first attempt to correlate these results with concurrent measurements of PMCs between 1982 and 1985. The results showed a weak, but positive, correlation suggesting that PMCs may be the birthplace of NLC particles. J. Olivero described five years of SME satellite observations of PMC. Removal of atmospheric background effects have improved on a previously published climatology. The analysis now reveals clearly the latitude-time boundaries of the occurrence of PMC, which are somewhat different from those of NLC. No longitudinal or geomagnetic latitude dependences are seen in the spatial distribution of PMC over the period 1982-1985. G. Witt reviewed the status of *in situ* techniques for measuring compositional and structural properties of the HLSM. He emphasized the importance of combining well-proven individual experiments into well-coordinated rocket campaigns, supported by modern ground-based radar probes. R. Keesee described the status of theories of nucleation of ice particles. Emphasizing the classical descriptions in lieu of more accurate but more complex and uncertain theories, he showed that both ion-induced nucleation and heterogeneous nucleation on meteoric dust are probably important for NLC nucleation. However the highly uncertain nucleation rates make it difficult to establish their relative importance. E. Kopp reviewed the state of rocket experimentation since 1963. Coordinated campaigns at Kiruna and Poker Flat have resulted in measurements (not all simultaneous) of the following properties: temperature, horizontal winds, ion composition, electron density, electrical conductivity and mobility, atomic oxygen density, NLC particle scattering, and solar UV absorption. He emphasized that future campaigns should concentrate on small-scale phenomena, and in particular on electrodynamic properties.

DISCUSSION

Various topics concerning NLC and the region of the atmosphere in which they form were covered in the discussion periods. The primary focus of these discussions was the microphysical properties of NLC and how they can be determined experimentally. Several related topics such as ion chemistry, the role of dynamics, and NLC climatology were also briefly discussed.

The discussions concerning NLC microphysics primarily focused on particle size and particle shape. G. Witt described rocket measurements of color ratio and degree of polarization which were fit to theoretical calculations assuming truncated log-normal particle size distribution. The results of this analysis indicated particle sizes no larger than 70 nm. He also pointed out that this result agrees very well with the analysis of SME data based on measurements at two UV wavelengths and various scattering angles.

However, M. Gadsden described the measurements which indicate that larger particles exist in NLC. Measurements of polarization in the clouds showed circular polarization in particular patches only, requiring particles which are a significant fraction of the wavelength of visible light. Also, Soviet cosmonauts detected strong forward scattering from NLC using IR photometers. Such strong forward scattering would require very large particles (up to 0.7 μm). However, this measurement was made only once and a detailed description was never published. G. Witt commented that he would like to see an independent measurement of the strong forward scattering.

Both M. Gadsden and R. Goldberg suggested the possibility that there could be a broad distribution of particle sizes with only a few large particles present. The large particles might only be detected by visible or IR measurements. Gadsden stated that only about 1 particle per cm^3 larger than 0.2 μm would account for the circular polarization measurements. However, J. Olivero commented that even 1 particle per cm^3 with this large a radius should have shown up in the SME data.

Several modeling studies of NLC indicate that spherical particles as large as 0.2 μm would be very unlikely to form. Essentially, the particles would fall out of the supersaturated region long before they grew large enough. In addition, J. Meriwether commented that there is not enough water vapor available for such large particles to grow. As pointed out by G. Reid, the available information seems to point to the existence of nonspherical particles, possibly long needles. Very irregular particles would have longer residence times and require less water vapor to achieve a particular linear dimension. However, G. Witt stated that ice particles forming at temperatures near 130 K are expected to be either amorphous or cubic. For either crystal structure, there is no *a priori* reason to expect highly irregular particles. M. Gadsden pointed out that if needle-shaped particles did form, they would preferentially survive.

The discussion on the topic of ion chemistry concentrated mainly on the variation in the ion composition near the mesopause. Rocket measurements have revealed that at 90 km, there is a very sharp transition between a region dominated by proton hydrate cluster ions at lower altitudes and molecular ions above. In addition, an order of magnitude discrepancy can exist between the electron density and the positive ion density, possibly due to the presence of negative ions or negatively charged aerosols.

Although PMC/NLC form only in the summertime high-latitude mesopause, G. Reid suggested that we should investigate whether the sharp variations that are seen occur at other seasons or at lower latitudes. S. Bowhill pointed out that a major uncertainty here is the role of dynamics. R. Garcia stated that if the sharp cutoffs do occur in both summer and winter, it would be difficult to invoke dynamics, temperature or breaking gravity waves to explain the sharp cutoff. This is because the circulation at mesopause altitudes changes so radically from summer to winter. He questioned what the connection might be between the charged particle composition and the sharp altitude variation in atomic oxygen that is known to occur in the upper mesosphere and lower thermosphere. G. Witt pointed out that the sodium layer also shows a sharp cutoff at 88 km, varying by an order of magnitude over less than one kilometer. He suggested that this also be considered in any theory of mesopause ion chemistry.

Another uncertainty is whether the proton hydrates play a role in cloud particle nucleation. G. Reid noted that since an enhanced electron density causes an increase in the recombination rate and thus cuts off the growth of cluster ions, the PMCs might be anticorrelated with the ionization rate due to particle precipitation. G. Thomas said that no one has successfully shown a correlation with PMCs or NLCs and geomagnetic activity. If anything, the PMCs observed by SME during the July 1982 solar proton event appeared to have been enhanced. Along these same lines, it was asked if there was any correlation between NLCs and meteor showers. M. Gadsden replied that meteor radar observations showed no obvious correlation.

Various questions were raised concerning the dynamics of the cold summertime mesopause. J. Olivero expressed concerns that we do not quite know what scales we want to look at since the clouds are generally very patchy. G. Witt emphasized the need for more cooperation between those who use zonally averaged models and those who consider small scale, local phenomena. D. Fritts agreed in light of the fact that vertical motion due to gravity waves can shift the particles up or down by about 1 km. Such a shift will move the particles into warmer or cooler regions of the atmosphere, and since particle growth rate is very sensitive to temperature, the cloud brightness should be affected.

M. McIntyre suggested the possibility that upwelling might enhance NLC brightness by suspending the particles. E. Jensen pointed out that modeling studies show that upward vertical wind will only moderately enhance NLC because even for the largest suggested upwelling velocities, a 50 nm particle will still have a significant fall speed. The more important effect of upward winds is transport of water vapor into the mesopause region. Given these comments, McIntyre suggested the possibility that synoptic-scale upwelling might transport H_2O into the region.

During the final discussion period, D. Rusch brought up the following question of whether there are any real differences between PMCs and NLCs, and if so what are the differences. G. Thomas replied the SME never detected a PMC brighter than the Rayleigh background at 55° latitude. Yet G. Witt has made a number of *in situ* photometer measurements which indicate NLCs as bright as 10 times the Rayleigh background, at approximately the same latitude. Since the viewing geometry is the same (within a factor of 2) for both techniques, there seems to be a real difference in brightness. The only real difference is that NLC are observed within several hours of local midnight, and PMC are observed at approximately 0400-0440 and 1370-1530 hours local time. As a possible explanation, recent PMC/NLC simulations carried out by E. Jensen and G. Thomas indicate on the order of a factor of 5 variation in cloud brightness with local time, with the cloud brightness peaking near local midnight. The principal driver in this variation is the diurnal and semidiurnal temperature variation.

D. Rusch asked if anyone has attempted to correlate simultaneous PMC and solar Lyman-alpha measurements made on SME. G. Thomas replied that this was done in a preliminary way, and no obvious correlations were seen. However, in view of the interesting prediction by R. Garcia that there should be a strong correlation, this analysis should be repeated.

In discussions concerning future measurements, there was agreement that in order to understand NLCs and related phenomena, simultaneous measurements of temperature, atomic oxygen concentration, electron density, and water vapor concentration are needed. The most difficult measurement to make is the vertical distribution of water vapor. Ground-based microwave measurements will not give the required height resolution in the 80-90 km region. Also, J. Olivero questioned whether the vertical resolution possible from satellite observations is sufficient for these observations.

Possible techniques for determining the size of NLC particles were also discussed, and G. Thomas stressed the need for a modern NLC spectrum. Gadsden pointed out that the problem with all ground-based NLC spectra is the necessity to correct for slant absorption between the observer and the clouds. Such a calculation requires an accurate knowledge of the ozone distribution. There was general agreement that a rocket-borne experiment should measure polarization and intensity from the visible down to 200 nm in order to detect the entire range of particle sizes.

During the Workshop, a number of areas for future research were identified: space measurements of the spectral and polarization properties of scattered light from NLC/PMC; measurements of HLSM properties made previously should be repeated, with the addition of measurements of water vapor, an extended positive ion mass spectrum, electric fields, ion mobility, small-scale wind structure, and ionization rate. Rayleigh lidar techniques have not yet reached the stage where they can measure the backscattering from clouds in daytime, although they should be capable of detecting clouds at night. Theoretical efforts should concentrate on more realistic microphysical cloud particle modeling and on calculating effects of winds, tides, and gravity waves on the clouds, the ion composition, the electric field, and the charge balance. The role of two-dimensional dynamical-photochemical models should be further examined; in addition, there is a need for simplified three-dimensional theoretical studies, which could expose mechanisms which are not present in the 2-D models. Although not specifically spelled out, it is clear that further laboratory measurements are needed for many of the ion-cluster reaction rates and their temperature dependence. Since many of the above measurements are planned for the (newly named) NLC90 rocket campaign, it is hoped that this effort will receive adequate financial support. For more information on this campaign, contact Dr. Richard Goldberg or Dr. Ernest Kopp.

REFERENCES

Garcia, R. G., and S. Solomon, The effect of breaking gravity waves on the dynamics and chemical composition of the mesosphere and lower thermosphere, *J. Geophys. Res., 90,* 3850-3868, 1985.

Kopp, E., and R. A. Goldberg, Rocket experiments and payloads for SUPER CAMP, Proc. 8th ESA Symp. on European Rocket and Balloon Programmes and Related Research, Sunne, Swe., 17-23 May 1987 (*ESA SP-270*)

Thomas, G. E., Solar Mesosphere Explorer measurements of polar mesospheric clouds (noctilucent clouds), *J. Atmos. Terr. Phys., 46*, 819-824, 1984.

PARTICIPANTS OF THE INTERNATIONAL NOCTILUCENT CLOUD WORKSHOP

O. Avaste, Tartu University (USSR)
S. K. Avery, University of Colorado (USA)
B. B. Balsley, NOAA (USA)
S. Blood, Pennsylvania State University (USA)
S. A. Bowhill, University of Lowell (USA)
G. Bjarnasson, NOAA (USA)
N. B. Brown, University of Alaska (USA)
P. Collis, EISCAT (SWEDEN)
R. Conway, Naval Research Laboratory (USA)
D. C. Fritts, University of Alaska (USA)
M. Gadsden, Aberdeen University (SCOTLAND)
K. S. Gage, NOAA (USA)
R. A. Goldberg, NASA Goddard Space Flight Center (USA)
L. Hale, Pennsylvania State University (USA)
C. Hall, The Auroral Observatory (NORWAY)
E. Jensen, University of Colorado (USA)
R. G. Keesee, Pennsylvania State University (USA)
E. Kopp, University of Bern (SWITZERLAND)
G. Lawrence, University of Colorado (USA)
J. London, University of Colorado (USA)
J. W. Meriwether, University of Michigan (USA)
H. Mitchell, Pennsylvania State University (USA)
J. J. Olivero, Pennsylvania State University (USA)
C. R. Philbrick, Pennsylvania State University (USA)
R. Prochaska, Xenia, OH (USA)
M. H. Rees, University of Alaska (USA)
G. C. Reid, NOAA (USA)
A. D. Richmond, NCAR (USA)
R. G. Roble, NCAR (USA)
J. Röttger, EISCAT (SWEDEN)
D. W. Rusch, University of Colorado (USA)
M. Sanford, Los Alamos Scientific Laboratory (USA)
W. E. Sharp, University of Michigan (USA)
R. Skrivanek, AFGL (USA)
S. Solomon, NOAA (USA)
K. Stamnes, University of Alaska (USA)
A. Stern, University of Colorado (USA)
G. E. Thomas, University of Colorado (USA)
R. J. Thomas, University of Colorado (USA)
P. Twitchell, Office of Naval Research (USA)
J. S. Van Baelen, NCAR (USA)
T. E. VanZandt, NOAA (USA)
U. Wälchi, University of Bern (SWITZERLAND)
J. Weinstock, NOAA (USA)
R. H. Wiens, York University (CANADA)
G. Witt, University of Stockholm (SWEDEN)

CUMULATIVE LISTING FOR THE MAP HANDBOOK

Volume	Contents	Publication Date
1	National Plans, PMP-1, PMP-2, PMP-3 Reports, Approved MAP Projects	June 1981
2	Symposium on Middle Atmosphere Dynamics and Transport	June 1981
3	PMP-5, MSG-1, MSG-2, MSG-3 Reports, Antarctic Middle Atmosphere Project (AMA), EXOS-C Scientific Observations, WMO Report No. 5., Updated Chapter 2 of MAP Planning Document, Condensed Minutes of MAPSC Meetings	November 1981
4	Proceedings of MAP Assembly, Edinburgh, August 1981 Condensed Minutes of MAPSC Meetings, Edinburgh, Proceedings of MAP Open Meeting, Hamburg, August 1981,	April 1982
5	A Catalogue of Dynamic Parameters Describing the Variability of the Middle Stratosphere during the Northern Winters	May 1982
6	MAP Directory	November 1982
7	Acronyms, Condensed Minutes of MAPSC Meetings, Ottawa, May 1982, MAP Projects, National Reports, Committee, PMP, MSG, Workshop Reports, Announcements, Corrigendum	December 1982
8	MAP Project Reports: DYNAMICS, GLOBUS, and SSIM, MSG-7 Report, National Reports: Czechoslovakia, USA	July 1983
9	URSI/SCOSTEP Workshop on Technical Aspects of MST Radar, May 1983, Urbana	December 1983
10	International Symposium on Ground-Based Studies of the Middle Atmosphere, May 1983, Schwerin	May 1984
11	Condensed Minutes of MAPSC Meetings, Hamburg, 1983, Research Recommendations for Increased US Participation in the Middle Atmosphere Program, GRATMAP and MSG-7 Reports	June 1984
12	Coordinated Study of the Behavior of the Middle Atmosphere in Winter (PMP-1) Workshops	July 1984
13	Ground-Based Techniques	November 1984
14	URSI/SCOSTEP Workshop on Technical Aspects of MST Radar, May 1984, Urbana	December 1984
15	Balloon Techniques	June 1985
16	Atmospheric Structure and its Variation in the Region 20 to 120 km: Draft of a New Reference Middle Atmosphere	July 1985
17	Condensed Minutes of MAPSC Meeting, Condensed Minutes of MAP Assembly, MAP Project, MSG, and National Reports	August 1985
18	MAP Symposium, November 1984, Kyoto	December 1985
19	Rocket Techniques	March 1986
20	URSI/SCOSTEP Workshop on Technical and Scientific Aspects of MST Radar, October 1985, Aguadilla	June 1986
21	MAPSC Minutes, ATMAP Workshop, Atmospheric Tides Workshop, MAP/WINE Experimenters Meetings, National Reports: Co-ordinated Study of the Behavior of the Middle Atmosphere in Winter	July 1986
22	Middle Atmosphere Composition Revealed by Satellite Observations	September 1986
23	Condensed Minutes of MAPSC Meetings, Toulouse, June/July 1986	December 1986
24	MAP Directory	May 1987
25	First GLOBMET Symposium, Dushanbe, August 1985	August 1987
26	MAPSC Minutes, Abstracts and Report of Workshop on Noctilucent Clouds, March 1988, Boulder	June 1988

CONTENTS